Emissions Analysis

Appendix A

The prospective analysis examines the emissions of eight air pollutants: volatile organic compound (VOC), nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter of ten microns or less (PM_{10}), particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$), ammonia (NH_3), and mercury (Hg). Changes in emissions of these pollutants were projected based on two emissions control scenarios: a) pre-1990 Clean Air Act Amendments ("Pre-CAAA") scenario assuming that no additional controls would be implemented beyond those that were in place when the CAAA were passed; and b) "Post-CAAA" scenario incorporating the effects of controls authorized by the 1990 Amendments. Comparison of the resulting projections revealed the predicted impact of the CAAA on emissions. In addition, these estimates provided the basis for the subsequent cost estimation and air quality modeling steps of the prospective analysis.

This appendix summarizes the Pre- and Post-CAAA emissions estimates for each of the major sources of VOC, NO_x, SO_2, CO, PM_{10}, $PM_{2.5}$, NH_3, and Hg and describes the methodology for the Agency's projections. EPA based its Pre- and Post-CAAA emissions estimates on projections from 1990 base year emissions estimates. For all of the pollutants, except particulate matter and mercury,[1] the Agency selected emissions levels taken from Version 3 of the National Particulates Inventory (NPI) to serve as the baseline. For both PM_{10} and $PM_{2.5}$, however, EPA updated NPI estimates to reflect the emissions from the National Emission Trends (NET) inventory. Once EPA finalized the base year levels, the Agency projected 1990 emissions to 2000 and 2010 under both the Pre- and Post- CAAA scenarios. At the time the emissions data base selection was made, the NPI was the most comprehensive source of emission estimates of all criteria pollutant emissions. Other available data sets, such as that available from the Ozone Transport Assessment Group (OTAG), were considered, but not selected because they were limited to ozone precursor emissions.

EPA estimated future emissions for all major source categories: industrial point sources, utilities, nonroad engines/vehicles, motor vehicles, and area sources. To make these projections, for all but utility sources, the Agency relied on emissions analysis that incorporated growth forecasts and future year control assumptions about rule effectiveness and control efficiency. In this analysis EPA projected growth largely based on anticipated changes in economic activity, and treated the rule effectiveness and the rate of control efficiency as the key differences between the Pre- and Post-CAAA scenarios.

EPA used the Integrated Planning Model (IPM) to estimate utility emissions. With this optimization model EPA forecasts emissions for the 48 contiguous States and the District of Columbia. All existing electric power generation units are covered in the model, as well as independent power producers and other cogeneration facilities that sell wholesale power, if they were included in the North American Electric Reliability Council (NERC) data base for reliability planning. The model considers future capacity additions by both utilities and independent power producers. In addition, this model is capable of producing baseline air emission forecasts and estimates of air emissions levels under various control scenarios at the national, and NERC region and subregional, level. A full explanation of the IPM model and the assumptions EPA used for this prospective analysis may be found in Analyzing Electric Power Generation under the CAAA, EPA, July 1996.[2]

This appendix first provides an overview of Pre- and Post-CAAA scenario development. It discusses

[1] A separate methodology was used to estimate mercury emissions. Mercury emissions are discussed independently beginning on page A-48 of this appendix.

[2] This document was updated in March 1998 to describe model refinements made for IPM Version 7.1 and the latest base case forecasts. (EPA, Office of Air and Radiation, Analyzing Electric Power Generation under the CAAA, March 1998.)

key factors influencing the 2000 and 2010 estimates, such as the timing of modeling decisions with respect to control programs and available data. In the following section, there is a comparison of the prospective analysis base year inventory and emissions projections with other existing data. Subsequent sections address the influence of Title 1 progress requirements and the major sources of uncertainty, and provide detailed breakdowns of emissions projections for the five major source categories responsible for air pollution: industrial point, utility, nonroad, motor vehicle, and area sources. For each of these source categories this appendix provides: (1) an overview of the approach used to make the emissions estimates; (2) a discussion of how base year emissions levels were determined; (3) an explanation of how growth projections were determined; (4) an outline of the assumptions made for the control scenarios; and (5) a summary of the emissions estimates for both the Pre- and Post-CAAA scenarios.

Scenario Development

EPA projected emissions by adjusting 1990 base year emissions to reflect projected economic activity levels in 2000 and 2010, and applying future year control assumptions. The resulting estimates depended largely upon three factors: how the base year inventory was selected, what indicators were used to forecast growth, and what specific regulatory programs were incorporated in the Pre- and Post-CAAA scenarios. These three factors are addressed in Tables A-1 through A-3. Table A-1 highlights the approach EPA used to establish the base year inventory. The indicators the Agency relied on to forecast growth and predict future activity levels, along with the analytical approach EPA used to project emissions, are shown in Table A-2. The Pre- and Post-CAAA regulatory scenarios are summarized in Table A-3.

Of the factors that influence EPA's emissions projections for 2000 and 2010, the most significant is the suite of air pollution regulations and programs the Agency incorporated in the Pre- and Post-CAAA scenarios. For the Pre-CAAA scenario, air pollution controls are frozen at their 1990 levels; only standards and initiatives implemented prior to the CAAAs are included. The Post-CAAA scenario, in addition to the measures contained in the Pre-CAAA scenario, incorporates emission controls associated with the 1990 Amendments. Due to the necessity of developing emissions scenarios early in the prospective analysis process, the exact provisions of some regulatory programs could not be foreseen. For example, decisions about how to translate the OTAG recommendations into regional NO_x control requirements had not been made, so estimates were made on affected sources, geographic coverage, and control levels.

EPA included in the Post-CAAA scenario:

- Title I VOC and NO_x reasonably available control technology (RACT) and reasonable further progress (RFP) requirements for ozone nonattainment areas (NAAs);
- Title II motor vehicle and nonroad engine/vehicle provisions;
- Title III 2- and 4-year maximum achievable control technology (MACT) standards;
- Title IV SO_2 and NO_x emissions programs for utilities;
- Title V permitting system for primary sources of air pollution; and
- Title VI emissions limits for chemicals that deplete stratospheric ozone.

This scenario also assumes the implementation of a region-wide NO_x cap and trade system for the entire OTAG domain[3] and a similarly designed trading program for the Ozone Transport Region (OTR) that is consistent with Phase II of the Ozone Transport Commission (OTC) NO_x Memorandum of Understanding (MOU). For motor vehicles, emission reductions associated with a 49-State low emission vehicle (LEV) program were also included in the Post-CAAA scenario. A more detailed outline of the controls included in both the Pre- and Post-CAAA scenarios is provided in Table A-3.

[3]The NO_x control program incorporated in the Post-CAAA scenario may not reflect the NO_x controls that are actually implemented in a regional ozone transport rule.

Table A-1
Base Year Inventory - Summary of Approach

Sector	Analysis Approach/Data Sources
Industrial Point Sources	1985 National Acid Precipitation Assessment Program (NAPAP) emissions inventory grown to 1990 based on historical Bureau of Economic Analysis (BEA) earnings data. PM_{10} emissions based on total suspended particulate (TSP) emissions and particle-size multipliers.
Utilities	The 1990 utility emission estimates are from the 1990 NPI.
Nonroad	Nonroad Engines/Vehicles (VOC, NO_x, CO, PM_{10}): 1991 Office of Mobile Sources (OMS) Nonroad Inventory. Nonroad Engines/Vehicles (SO_2) and Aircraft, Commercial Marine Vessels, Railroads: 1985 NAPAP grown to 1990 based on historical BEA earnings data.
Motor Vehicles	Federal Highway Administration (FHWA) travel data, MOBIL5a/PART5 emission factors.
Area Sources	1985 NAPAP inventory grown to 1990 based on historical BEA earnings data and State Energy Data Systems (SEDS) fuel use data; emission factor changes for selected categories.

Table A-2
Analysis Approach by Major Sector

Sector	Growth Forecast	Analysis Approach
Industrial Point	1995 BEA Gross State Product (GSP) Projections by State/Industry.	VOC, NO_x — Emission Reduction and Cost Analysis Model (ERCAM): applies BEA growth projection to base year emissions and applies future year controls as selected by the user. PM_{10}, SO_2, CO — While no formal model exists, the same basic approach applied in ERCAM was used for these pollutants.
Utilities	Projections of heat input by unit based on National Electric Reliability Council (NERC) data, price and demand forecasts, and technology assumptions.	SO_2, NO_x — Integrated Planning Model (IPM). VOC, PM_{10}, CO — Base year emissions rates or AP-42 emission factors applied to IPM projected heat input by unit.
Nonroad	1995 BEA GSP and Population Projections by State/Industry.	VOC, NO_x — ERCAM. PM_{10}, SO_2, CO — ERCAM approach (no formal model).
Motor Vehicles	MOBILE Fuel Consumption Model (FCM) National Vehicle Miles Traveled (VMT) Projection Scaled to Metropolitan/REST-of-State Areas by Population.	NO_x, VOC, CO — ERCAM: applies MOBIL5a emission factors to projected VMT by month and county/vehicle type/roadway classification. PM_{10}, SO_2 — PART5 emission factors applied to projected VMT.
Area	1995 BEA GSP and Population Projections by State/Industry, and USDA Agricultural Projections.	VOC, NO_x — ERCAM. PM_{10}, SO_2, CO — ERCAM approach (no formal model).

Table A-3
Projection Scenario Summary by Major Sector

Sector	Pre-CAAA	Post-CAAA*
Industrial Point	RACT held at 1990 levels.	VOC and NO_x RACT for all NAAs (except NO_x waivers). New control technique guidelines (CTGs) (VOC). 0.15 pounds per million British thermal unit (lbs/MMBtu) OTAG-wide NOx cap on fuel combustors of 250 MMBtu per hour or above(NO_x). OTAG Level 2 NO_x controls across OTAG States (NO_x). 2- and 4- year MACT standards (VOC). Ozone Rate-of-Progress (3 percent per year) requirements (further reductions in VOC).
Utilities	250 ton prevention of Significant Deterioration (PSD) and New Source Performance Standards (NSPS) held at 1990 levels. RACT and New Source Review (NSR) held at 1990 levels.	Title IV SO_2 emission allowance program (SO_2). Title IV Phase I and Phase II emission limits for all boiler types (NO_x). 250 ton PSD and NSPS. RACT and NSR for all non-waived (NO_x waiver) NAAs (NO_x). Phase II of the Ozone Transport Commission (OTC) NOx memorandum of understanding (MOU) (NO_x). 0.15 lbs/MMBtu OTAG-wide seasonal NO_x cap with banking/trading (NO_x).
Nonroad	Controls (engine standards) held at 1990 levels.	Federal Phase I and II compression ignition (CI) engine standards (NO_x, PM). Federal Phase I and II spark ignition (SI) engine standards (VOC, CO, NO_x). Federal locomotive standards (NO_x, PM). Federal commercial marine vessel standards (NO_x). Federal recreational marine vessel standards (VOC, NO_x).
Motor Vehicles	Federal Motor Vehicle Control Program (FMVCP) — engine standards set prior to 1990. Phase 1 Reid vapor pressure (RVP) limits. I/M programs in place by 1990.	Tier 1 tailpipe standards (Title II) (VOC, NO_x). 49-State LEV program (Title I) (VOC, NO_x, CO). Phase 2 RVP limits (Title II) (VOC). I/M programs for ozone and CO NAAs (Title I) (VOC, NO_x, CO). Federal reformulated gasoline for ozone NAAs (Title I) (VOC, NO_x, CO). California LEV (California only) (Title I) (VOC, NO_x, CO). California reformulated gasoline (California only) (Title I) (VOC, NO_x, CO). Diesel fuel sulfur content limits (Title II) (SO_2, PM). Oxygenated fuel in CO NAAs (Title I) (CO).

Table A-3
Projection Scenario Summary by Major Sector

Sector	Pre-CAAA	Post-CAAA*
Area	Controls held at 1990 levels.	VOC and NO_x RACT requirements. New CTGs (VOC). 2- and 4- year MACT standards (VOC). Ozone Rate-of-Progress (3 percent per year) requirements (further reductions in VOC). PM NAA controls (PM). Onboard vapor recovery (vehicle refueling) (VOC). Stage II vapor recovery systems (VOC).

*Also includes all Pre-CAAA measures.

Decisions about which control programs to include in the Post-CAAA scenario and how their emission reductions were modeled, were made during the summer of 1996. While some adjustments to the emission projection methods were made since that time in response to review comments, opportunities were not available to revise the emission projections once air quality modeling was initiated using these data sets. The result is that there are some differences between the emissions modeling practices being used currently in EPA regulatory analyses and those reflected in the Section 812 Prospective. As examples, the VOC emission reductions of 7 and 10 year MACT standards are not included in the Prospective, nor are CO, NO_x, SO_2, and PM emission benefits of any MACT standards. Similarly, the NO_x State Implementation Plan (SIP) Call affects 22 States, not 37, and OTAG Level 2 controls are not applied to all non-electrical generating units (EGUs) NO_x sources, only to cement kilns and internal combustion engines.

Comparison of the Base Year Inventory and Emissions Projections with Other Existing Data

Comparison of the emissions estimates in the prospective analysis to historical emissions estimates drawn from EPA's National Air Pollutant and Emissions Trends reports (hereafter referred to as *Trends*) can provide a check on the reasonableness of our emissions inventories. In addition, comparison of emissions projections from the prospective analysis with those of the Grand Canyon Visibility Transport Commission (GCVTC) study of western regional haze (Radian, 1995; Science & Policy Associates, 1995; Argonne, 1995) provides an initial test of the sensitivity of emissions projections to baseline inventories and growth assumptions. Analysis of PM emissions and comparison of estimated PM data with observed PM data presented in the 1997 National Air Quality and Emissions Trends Report (EPA, 1998a) also helps evaluate the prospective study's emissions estimation methods.

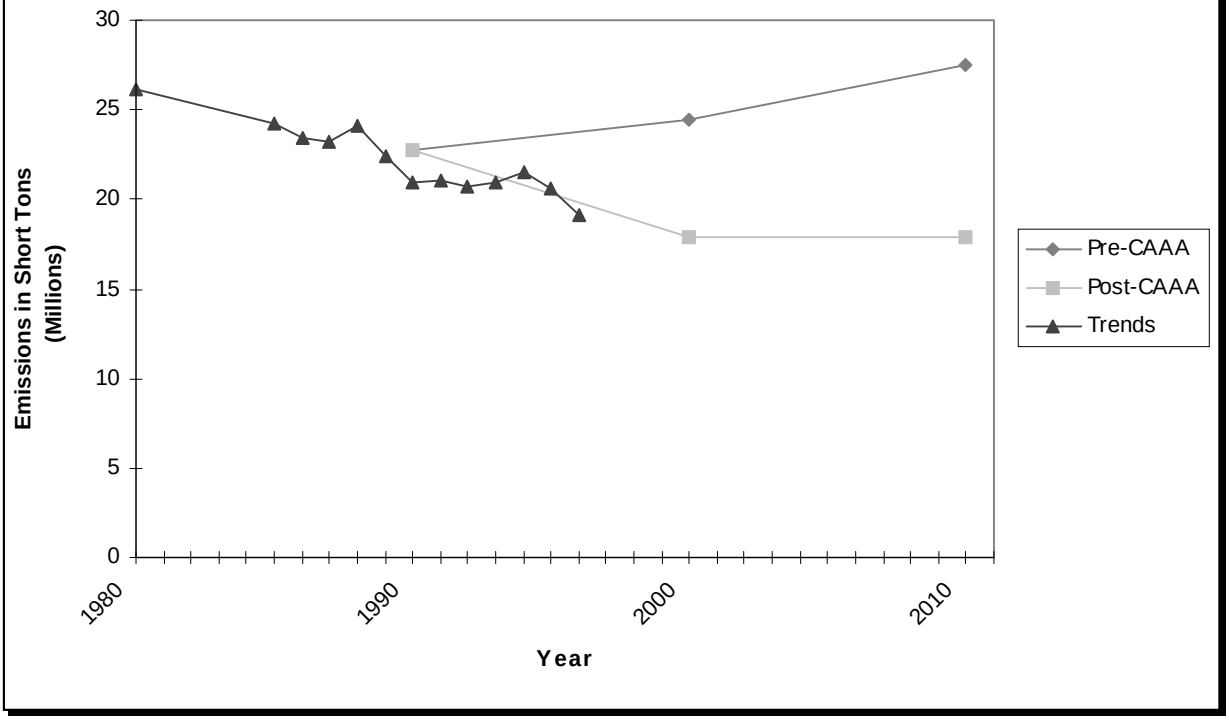
Post-CAAA Emissions Estimates and EPA Trends *Data*

EPA publishes annual National Air Pollutant Emission Trends reports that contain estimates of historical trends in emissions of VOC, NO_x, SO_2, CO, PM_{10}, and lead (Pb). Comparison of the *Trends* (EPA, 1997a) and Post-CAAA estimates reveals that from 1990 to 1995, VOC, NO_x, SO_2, CO, and PM_{10} emissions figures from both are similar.

Figures A-1 through A-5 display the Pre-CAAA, Post-CAAA, and *Trends*, emissions estimates for VOC, NO_x, SO_2, CO, and PM_{10} respectively. Although the Post-CAAA and *Trends* emissions trends are comparable for all five of these pollutants, there are several instances where there are differences between the estimates from these two different sources. VOC emissions are highly variable from year to year. To illustrate this fluctuation, annual *Trends* estimates, and five year *Trends* increments, are provided in Figure A-1 for the years 1985 to 1996. Although the 1990 *Trends* estimate is lower than the prospective analysis' base year inventory, the general emissions trend projected under the Post-CAAA scenario is similar to that represented by the historical EPA estimates .[4]

[4]VOC emissions estimates not only fluctuate from year to year, but also from *Trends* report to *Trends* report. Had the *Trends* report published in October of 1996, a year earlier, been used as the data source for Figure A-1, the 1990 *Trends* VOC estimate would have been higher, not lower, than the prospective analysis' base year inventory.

Figure A-1. Comparison of Pre-CAAA, Post-CAAA, and *Trends* VOC Emissions Estimates



As shown in Figure A-2, the 1995 *Trends* estimate for NO_x emissions exceeds the Post-CAAA NO_x projection. The primary influence on NO_x emissions in the mid-1990s was the requirement to install RACT on major stationary source NO_x emitters in certain ozone nonattainment areas, and the Northeast OTR. Because the EPA *Trends* report is still in the process of incorporating the State's 1996 periodic emission inventories in the NET data base, it is believed that the *Trends* values in Figure A-2 do not capture all of the NO_x emission reductions that have occurred to date. When these State data are incorporated in *Trends*, it is expected that the 1990 to 1996 NO_x emissions trend line will more closely parallel the Post-CAAA estimates.

Comparison of SO_2 Post-CAAA and *Trends* estimates based upon the profiles plotted in Figure A-3 shows that the 1995 *Trends* estimates are somewhat lower than the corresponding prospective projection line. This is because the *Trends* profile reflects the sudden reduction in SO_2 emissions that resulted from the implementation of the acid rain SO_2 trading program in the early 1990's. While this reduction is incorporated in the Post-CAAA scenario, it is not captured until the year 2000 emissions projections; plotting the corresponding trend line has the effect of distributing these early reductions over the entire decade in constant annual increments. Between 1995 and 2000 the actual rate of SO_2 reduction will almost certainly slow so that by the year 2000 Post-CAAA and *Trends* estimates will be much more comparable than the 1995 levels depicted in Figure A-3.

Post-CAAA and *Trends* emissions estimates for CO (Fig. A-4) and PM_{10} (Fig. A-5) respectively are similar for the years 1990 and 1995. For PM_{10}, the values used to develop the Pre- and Post-CAAA, and *Trends* profiles were adjusted to eliminate the influence of wind erosion, a natural source of PM_{10} that can cause significant fluctuation in emission estimates from year to year. Even though this source is

controlled for, there is still significant variability in the yearly historical PM_{10} emissions estimates. To capture this variability in the *Trends* estimates, instead of providing estimates at five year increments, annual *Trends* emissions levels are displayed in Figure A-5. For the years since the adoption of the 1990 CAAA, both the *Trends* estimates and the Post-CAAA scenario projections show PM_{10} emissions remaining at the same relative level. The drastic drop in the *Trends* line from 1989 to 1990 is the result of a change in methodology used to calculate PM_{10} emissions.

Figures A-1 through A-5 contain *Trends* estimates for 1980 and 1985 in addition to the 1990 and 1995 values primarily discussed above. This information is included to provide a broader picture of actual emissions levels over the last 15 years and to show how the general historical trends in emissions compare to the projected future trends under both the Pre- and Post-CAAA scenarios. Close comparison of pre-1990 *Trends* estimates with 1990 to present *Trends* estimates and prospective analysis projections, however, has the potential to be misleading. Beginning in 1990 there was a significant change in the methodology used to estimate *Trends* emissions. The 1980 and 1985 figures presented here are intended only for general comparison.

Figure A-2. Comparison of Pre-CAAA, Post-CAAA, and *Trends* NO_x Emissions Estimates

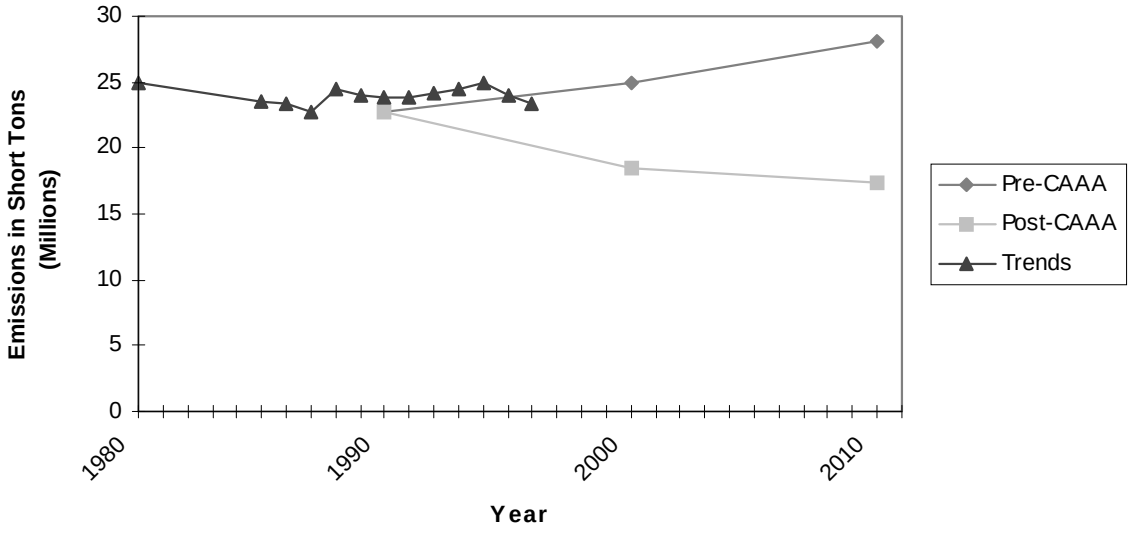


Figure A-3. Comparison of Pre-CAAA, Post-CAAA, and *Trends* SO Emissions Estimates

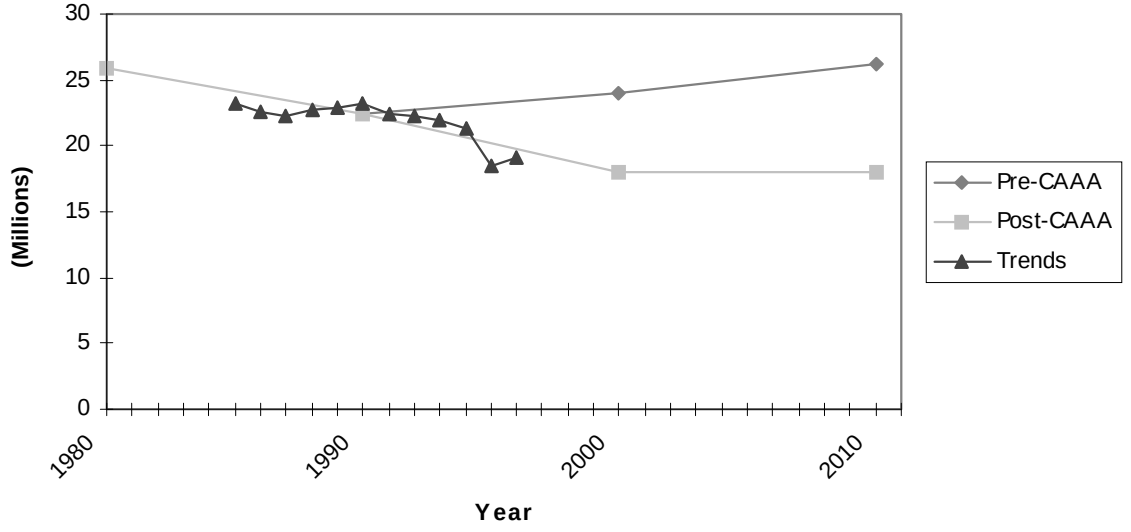


Figure A-4. Comparison of Pre-CAAA, Post-CAAA, and *Trends* CO Emissions Estimates

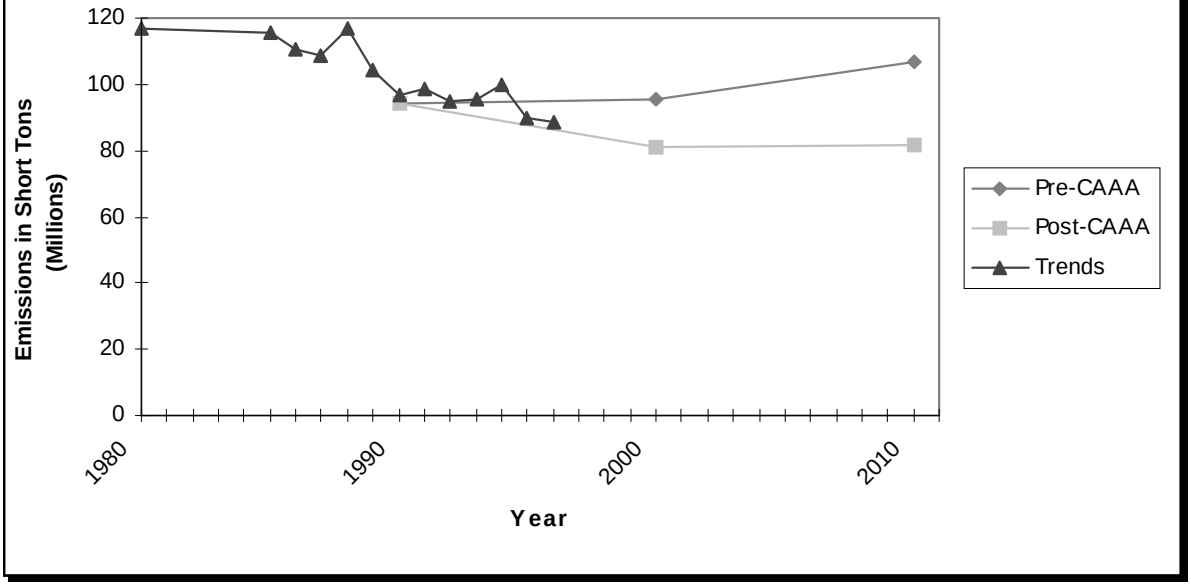
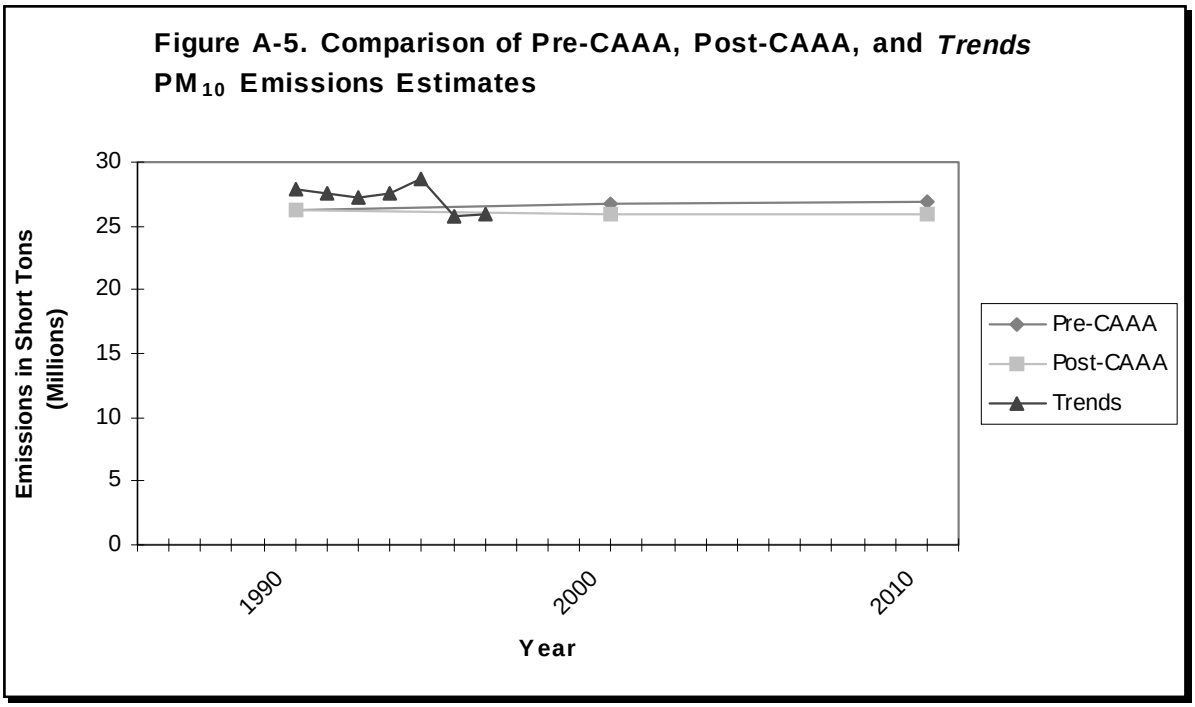


Figure A-5. Comparison of Pre-CAAA, Post-CAAA, and *Trends* PM_{10} Emissions Estimates



Prospective Analysis and GCVTC Emissions Estimates

The GCVTC conducted, for the Western States, an air pollution analysis that projected emissions for selected pollutants from 1990 base year levels for the year 2000 and every tenth subsequent year up to 2040. Comparison of the 2000 and 2010 GCVTC study and prospective analysis Post-CAAA scenario projections for the Western States indicate that although their estimates for NO_x, SO_2, and $PM_{2.5}$ are somewhat different, these differences arise from the use of different baseline inventories in the two studies, or from specific regional reductions not incorporated in the prospective study scenarios (Table A-4).

NO_x and SO_2 base year figures in the prospective analysis are approximately 10-15 percent higher than the corresponding estimates in the GCVTC study. The difference is most likely the result of the separate inventories that are relied upon by the two analyses to develop their respective base year emissions levels. Version 3 of the NPI, the primary source of base year emissions data for the prospective analysis, is largely derived from 1985 emissions figures that are adjusted to 1990 levels using BEA growth projections. This inventory does not capture the effect of new controls and technology change on emissions between 1985 and 1990. The GCVTC base year estimates for NO_x and SO_2, based primarily on State provided point source emissions figures from one of the years 1990 to 1992, however, incorporate these effects. As a result, 1990 emissions estimates in the GCVTC study are lower than those in the prospective analysis.

Due to the difference in the two studies' base year NO_x estimates, their projected absolute levels of NO_x emissions also differ. Both studies, however, estimate that NO_x pollution will decrease at a similar rate from 1990 levels. The prospective analysis Post-CAAA scenario shows a 16 percent drop by the year 2010, while the GCVTC estimates a 17 percent reduction.

SO_2 projections for the two studies are not characterized by similar percentage changes in emissions. In fact, under the Post-CAAA scenario the prospective analysis estimates an increase in SO_2 emission from 1990 to 2010 of about 15 percent, while the GCVTC study shows roughly an 11 percent decrease over this same time period. The reason for this disparity is that only the GCVTC emissions forecasts take into account specific modernization plans for the Kennecott-Utah Copper Corporation which are predicted to lower future SO_2 emissions in the West by approximately 30 thousand tons per year (tpy), as well as, a regional electric utility cut of roughly 80 thousand tpy. Together, these anticipated reductions account for the bulk of the difference between the two studies future year estimates.

Emissions figures for $PM_{2.5}$ are the source of the largest disparity between the prospective analysis and the GCVTC study. In general, emissions estimates are roughly 40 percent lower in the former than in the latter. This is due to a difference in the inventories used to develop the 1990 base year $PM_{2.5}$ estimates. While the more recent prospective analysis relied on NPI data that was updated to incorporate NET estimates that reflected revisions to $PM_{2.5}$ emissions factors for fugitive dust, the GCVTC study was conducted prior to the lowering of these factors. As a result, the $PM_{2.5}$ estimates in the GCVTC study are considerably higher than those in the prospective analysis. The percent change in $PM_{2.5}$ emissions from 1990 to 2010, however, is similar in the two studies (approximately 10 percent in prospective analysis and approximately 13 percent in GCVTC study).

Table A-4
Comparison of Emissions: Prospective Analysis and GCVTC Stud

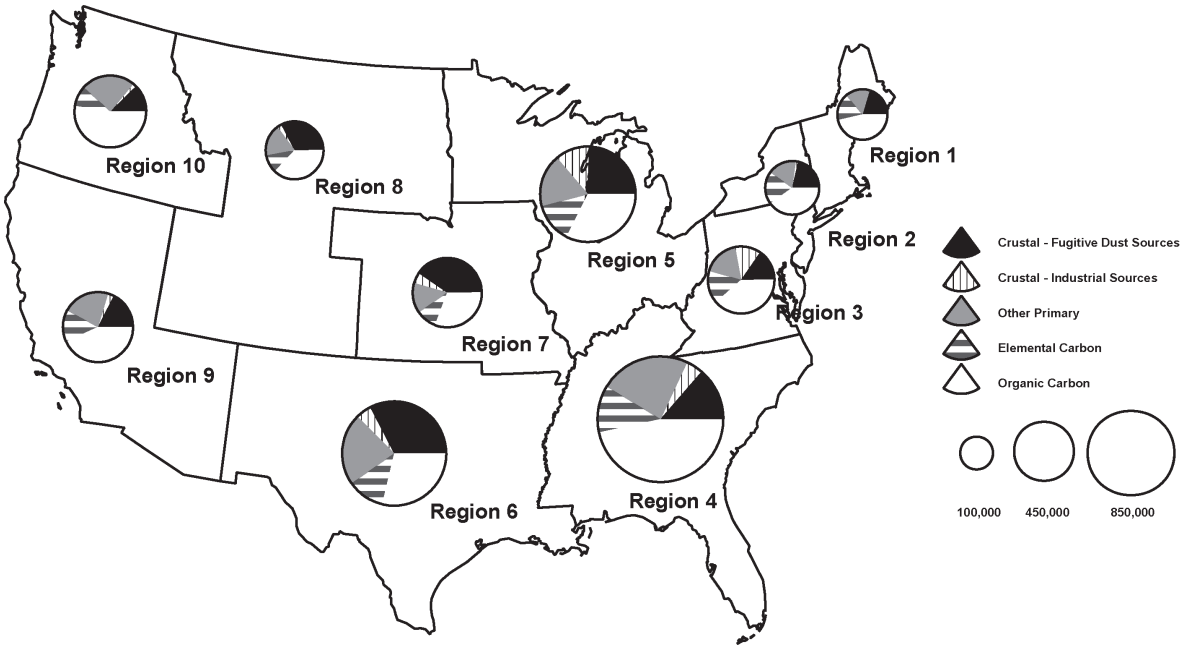
	1990		2000		2010	
	Post-CAA	GCVTC	Post-CAA	GCVTC	Post-CAA	GCVTC
NO_x	3,303,536	3,058,221	2,938,833	2,596,409	2,784,580	2,532,855
SO_2	1,245,439	1,094,928	1,326,546	944,689	1,434,470	970,762
$PM_{2.5}$	1,701,869	2,412,177	1,759,434	2,535,829	1,864,656	2,730,304

NOTE: The figures in this table represent the total annual emissions (tons per year) for the Western States: Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming.

Prospective Analysis $PM_{2.5}$ Emissions Estimates and Observed Data

The 1997 National Air Quality and Emissions Trends Report provides a summary of $PM_{2.5}$ concentration speciation data. This report shows the relative contribution of the major PM emissions source components (crustal material, carbonaceous particles, nitrate, and sulfate) to ambient $PM_{2.5}$ concentrations in urban and nonurban areas throughout the U.S. Comparison of primary $PM_{2.5}$ emissions estimates generated for this analysis with the observed concentration data presented in the 1997 report indicates that the ratio in the prospective study of crustal material to primary carbonaceous particles is high. At least part of this apparent overestimation

Figure A-6
1990 Primary PM2.5 Emissions by EPA Region (tons/year)



of crustal material and underestimation of carbonaceous particulates, however, is due to the fact that much of the emitted crustal material quickly settles and does not have a quantifiable impact on ambient air quality. In this analysis, we apply a factor of 0.2 to crustal emissions to estimate the fraction of crustal $PM_{2.5}$ that makes its way into the "mixed layer" of the atmosphere and influences pollutant concentrations. Figure A-6 displays the breakout of primary $PM_{2.5}$ into its adjusted crustal and carbonaceous (elemental carbon (EC) and organic carbon (OC)) components. The figure divides crustal material into two subcategories based on the source of the material (fugitive dust or industrial sources) and also shows the portion of primary $PM_{2.5}$ that is neither crustal nor carbonaceous. The ratios, one for each EPA Region, of adjusted crustal material to primary carbonaceous particles presented in Figure A-6 are in line with the observed $PM_{2.5}$ concentration data presented in the 1997 report.

Industrial Point Sources

This section addresses industrial sector emitters – boilers and processes – that are large enough to be included in the 1990 emissions data base as individual point sources. In most cases, these are facilities that emit more than 100 tons per year of at least one criteria air pollutant. For industrial point source VOC and NO_x emitters, trend analysis using the Emission Reduction and Cost Analysis Model (ERCAM) was conducted to project emissions for the years 2000 and 2010 (Pechan, 1994a; 1994b). The same procedures employed in the VOC and NO_x projections were also used in developing CO, SO_2, and PM_{10} estimates.

Overview of Approach

In order to estimate the combined effects of activity growth and CAA controls on industrial point sources, the base year 1990 point source inventory was projected to 2000 and 2010 using growth factors from the Bureau of Economic Analysis (BEA), and CAA control assumptions. In its guidance for projecting emissions by combining growth and control effects, EPA identifies the following two options:

1. Aggregating all base year emissions and control information at the county level and performing all projections on that basis; or

2. Retaining source-specific information in the base year inventory and performing projections on a source-by-source basis (EPA, 1991a).

The second of these two approaches was selected, and future year emissions were projected by multiplying source-specific base year emissions by a corresponding growth factor and control factor. The decision to follow this option was based on the need to use source-level emissions estimates as the input for the air quality modeling phase of the prospective analysis.

The growth factors used in this analysis for projecting industrial point source emissions are from 1995 BEA industry-level Gross State Product (GSP) and population projections by State (BEA, 1995). ERCAM was used to model VOC and NO_x emissions under each of the control scenarios. The basic approach for projecting emissions in ERCAM is as follows:

$$EMIS_Y = EMIS_{90} * GFAC_Y * \left[\frac{1 - (RE_Y * CE_Y)}{1 - (RE_{90} * CE_{90})}\right]$$

where:

$EMIS_Y$	=	Emissions in projection year y
$EMIS_{90}$	=	1990 base year emissions
$GFAC_Y$	=	Growth factor for projection year y
RE_Y	=	Future year rule effectiveness (RE)
CE_Y	=	Future year control efficiency
RE_{90}	=	Base year (1990) RE
CE_{90}	=	Base year (1990) control efficiency

In cases where the future year control level (RE_Y * CE_Y) is less stringent than the base year control level, 1990 base year control levels are retained (i.e., RE_Y and CE_Y equal 1990 levels in the emission projection algorithm).

Base Year Emissions

The base year 1990 point source emission inventory for the prospective analysis is Version 3 of the NPI, originally developed in 1994 as a component of the Office of Policy, Planning and Evaluation (OPPE)'s "National Particulate Matter Study" (Pechan, 1994c; Pechan, 1995a). The NPI is a 1990 air emissions inventory for the United States (excluding Alaska and Hawaii). This data base contains plant and process level emissions for each of the criteria pollutants examined in this analysis.

Industrial point source emissions in the NPI were estimated using emission estimates from the 1985 National Acid Precipitation Assessment Program (NAPAP) Inventory projected to 1990 using BEA industrial sector earnings. Emission estimates for 1985 were projected to 1990 based on the State-level growth in earnings by industry (2-digit Standard Industrial Classification (SIC) code). Each record in the point source inventory was matched with the BEA earnings data based on the State and the 2-digit SIC code.

The industrial sector 1990 emission estimation procedures do not account for technological improvements since 1985 that may have lowered emissions per unit of production/output, nor do they account for emission controls that were added during this period. As a result, the base year emissions estimates, if biased, may overstate industrial point source emissions for 1990. In the Western States, with the incorporation of the GCVTC estimates, the 1990 emissions baseline for this region of the country may be less biased. The reason for this is that the GCVTC inventory is based upon State-supplied emissions information covering one of the years from 1990 to 1992. These more recent State reports reflect the effects of technological improvements and emission controls of the latter half of the 1980's that the NPI baseline inventory does not capture.

The NAPAP Inventory does not contain PM_{10} and $PM_{2.5}$ emissions estimates. As a result, the annual PM_{10} and $PM_{2.5}$ emissions figures in the NPI were calculated from 1985 total suspended particulate (TSP) emissions. These 1985 TSP estimates were projected to 1990 using BEA data and emissions estimates from each point source in the NAPAP Inventory (excluding steam electric utilities). What portion of 1990 TSP emissions was PM_{10} and what portion was $PM_{2.5}$ was then determined. In order to make this determination, however, the 1990 TSP estimates first had to be adjusted to eliminate the effect of particulate controls, because in order to estimate particle size distribution using EPA's *Compilation of Emission Factors* (EPA, 1995), uncontrolled source data were required. Once this adjustment was made, PM_{10} and $PM_{2.5}$ emissions were calculated by applying a Source Classification Code (SCC)-specific particle size distribution factor to the 1990 "uncontrolled" TSP emissions estimates. Then, the effects of primary and secondary controls on the two pollutants were estimated and base year PM_{10} and $PM_{2.5}$ emissions were calculated.

Growth Projections

The base year 1990 point source emission inventory was projected to 2000 and 2010 to determine the effects of Pre-CAAA and Post-CAAA controls on future year emission levels. Point source emissions growth is based on 1995 BEA industry GSP and population projections by State (BEA, 1995). EPA guidance for projecting emissions (EPA, 1991a) lists the following economic variables (in order of preference) for projecting emissions:

- Product output;
- Value added;
- Earnings; and
- Employment.

In the absence of product output projections, EPA guidance recommends value added projections. *Value*

added is the difference between the value of a firm's output and the inputs it purchases from other firms. BEA GSP projections represent a measure of value added, and are a fuller measure of growth than BEA's earnings projections because earnings represents only one component of GSP. GSP measures reflect the value added to revenue from selling a product minus the amounts paid for inputs from other firms. By incorporating inputs to production, GSP reflects future changes in production processes, efficiency, and technological changes. A comparison of BEA's 1995 GSP projections and BEA's 1990 earnings projections indicates that GSP growth factors are slightly higher than the earnings data. This is more often true for capital-intensive industries (e.g., manufacturing) than for labor-intensive industries (e.g., services). Components of GSP include payments to capital. This is an important distinction to make because it implicitly reflects the effect of factor substitution in production. As discussed in EPA's projections guidance, factor substitution should be included in growth projections, making value added data preferable to earnings data for projecting emissions.

For reasons mentioned above, the 1995 BEA industry GSP and population projections by State (BEA, 1995) were selected as the best available growth factors for projecting 1990 emissions to 2000 and 2010 for the prospective analysis. BEA's GSP estimates are broken down by industry sector (2-digit SIC codes) and State. For each record in the industrial point source component of the NPI, a link was established between the State code, the SIC code field, and the BEA GSP growth factors. Then projected future year emissions for each point source record were calculated by multiplying the 1990 emissions by the corresponding BEA growth factor.

BEA GSP growth factors were used to project industrial point source emissions for the prospective analysis because BEA data provide growth by industry on a State-level in a form that provides a straightforward link to the industrial point source component of the NPI (the SIC code field). GSP growth factors also comply with EPA's guidance for projecting emissions, since they represent a measure of *value added.* In the development of the BEA GSP projections, BEA ensures consistency with national projections of population from the Bureau of the Census, of the labor force from the Bureau of Labor Statistics (BLS), of the unemployment rate from the Congressional Budget Office, and of mining output from the Department of Energy (DOE). It is important to note, however, that BEA's projections are based on the assumption that past economic relationships will continue and that no major policy changes will occur. The growth factors used in this analysis therefore do not explicitly reflect potential future changes in economic conditions or technologies except those that may be reflected in historical industry trends.

Control Scenarios

The Pre-CAAA scenario represents expected point source emissions after the application of BEA GSP growth factors, with 1990 levels of control efficiency retained. The Post-CAAA scenario incorporates control efficiencies based on measures mandated by the CAAA. The control assumptions associated with each of the two scenarios are described separately below.

Pre-CAAA Scenario

The Pre-CAAA scenario assumes the continuation of 1990 control efficiencies for all emitters. Point source emissions of VOC, NO_x, CO, SO_2, PM_{10}, $PM_{2.5}$, and NH_3 under the Pre-CAAA scenario were projected to 2000 and 2010 by applying BEA GSP growth factors to the base year 1990 point source emission inventory based on the State and SIC code data fields.

Post-CAAA Scenario

The Post-CAAA scenario represents point source emissions after the application of BEA GSP growth factors, and the effects of controls implemented under the CAAA. CAAA provisions affecting industrial point sources include:

- Title III 2-year and 4-year MACT standards (VOC only);
- VOC and NO_x RACT requirements in ozone NAAs;
- New control technique guidelines (CTGs);
- A 0.15 lbs/MMBtu NO_x cap on fuel combustors of 250 MMBtu per hour or above across the OTAG 37-State region; and
- Ozone rate-of-progress (ROP) requirements.

The control assumptions used to estimate emissions from industrial point sources under the Post-CAAA scenario differ by pollutant. For each of the pollutants, the corresponding controls assumed to effect emissions in 2000 and 2010 are briefly described in Table A-5.

Table A-5
Industrial Point Source Control Assumptions For The Post-CAAA Scenario

Pollutant	Point Source Control Measures
VOC	Point source control measures for VOC include RACT, new CTGs, and Title III MACT controls. Title III MACT controls are generally as stringent, or more stringent, than RACT controls and are thus the dominant control option for many source categories. An 80 percent RE is assumed for all control measures.
NO_x	Industrial point source NO_x controls include NO_x RACT, OTAG level 2 NO_x controls, and a 0.15 lbs/MMBtu cap on fuel combustors of 250 MMBtu per hour and above across the OTAG 37-State region. Major stationary source NO_x emitters in marginal and above NAAs and in the northeast Ozone Transport Region (OTR) are required to install RACT-level controls under the ozone nonattainment-related provisions of Title I. RACT control levels are specified by each State and are based on an assumed rule effectiveness (RE) of 80 percent.
CO	No new CO controls were modeled for the Post-CAAA scenario, although some CO NAAs may have adopted controls for specific point sources within NAAs.
SO_2	SO_2 nonattainment provisions of the CAAA do not specify any mandatory controls for SO_2 emitters, though an emission cap of 5.6 million tons of SO_2 per year was set by the CAAA for industrial sources.
PM_{10} and $PM_{2.5}$	Possible control initiatives for particulates under the CAA would result from the Title I provisions related to PM_{10} nonattainment. Because the controls are specific to each area, the CAAA PM_{10} emissions for industrial point sources were assumed to be equivalent to the Pre-CAAA emissions. Point source $PM_{2.5}$ emissions were also assumed to be unaffected by CAAA provisions.
NH_3	Point source NH_3 emissions were assumed to be unaffected by CAAA provisions.

Emission Summary

National point source emission projections for 2000 and 2010 for each of the pollutants are shown in Table A-6. VOC emissions from industrial point sources in these two years are primarily affected by new National Emission Standards for Hazardous Air Pollutants (NESHAPs) under Title III and new CTGs for achieving further VOC emission reductions in ozone NAAs. Source categories with significant VOC emission reductions in this sector include chemical and allied product manufacturing, petroleum refineries, solvent utilization, and petroleum storage.

NO_x emission reductions from industrial fuel combustors result mainly from the implementation of RACT for major stationary sources in ozone NAAs and addition of further NO_x controls for large fuel combustors (larger than 250 MMBtu per hour) throughout the 37 OTAG States. The OTAG stationary source NO_x strategy included in this analysis assumes that large fuel combustors meet a 0.15 lbs/MMBtu NO_x emission limit. With these and other standards, CAA NO_x emission benefits in 2010 for this sector are projected to be more than one million tons.

Industrial point source emission projections for the other criteria pollutants (CO, SO_2, PM_{10}, $PM_{2.5}$, and NH_3) show no appreciable effect of the CAAA on future year emissions. Stationary source CO emitters could be subjected to further control requirements as part of individual area CO State Implementation Plans (SIPs), but this is unlikely. Similarly for PM_{10}, there may be industrial source PM_{10} emission reductions observed through application of best available control measures in some PM_{10} attainment plans, but these potential reductions are not captured in this analysis.

Table A-6
Industrial Point Source Emission Summaries by Pollutant For 1990, 2000, and 2010* (thousand tons per year)

Pollutant/Source Category	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
VOC					
Fuel Comb. Industrial	126.1	135.9	134.9	153.7	157.7
Fuel Comb. Other	10.3	12.3	12.3	14.4	14.9
Chemical & Allied Product Mfg	1,066.2	1,101.4	878.9	1,266.6	1,007.4
Metals Processing	72.5	85.8	83.1	90.3	87.2
Petroleum & Related Industries	238.2	243.1	160.2	269.5	166.7
Other Industrial Processes	327.0	372.5	365.3	418.9	417.3
Solvent Utilization	1,126.2	1,256.7	1,036.0	1,394.1	1,120.0
Storage & Transport	490.1	540.9	405.7	617.0	467.5
Waste Disposal & Recycling	9.7	9.9	9.9	11.1	11.7
Miscellaneous	0.3	0.4	0.4	0.6	0.6
TOTAL	3,466.6	3,758.9	3,086.7	4,236.2	3,450.9
NO_x					
Fuel Comb. Industrial	1,955.8	2,181.8	1,213.5	2,464.5	1,255.9
Fuel Comb. Other	103.9	122.9	77.4	141.1	84.1
Chemical & Allied Product Mfg	275.4	281.5	263.0	322.2	300.0
Metals Processing	81.0	103.0	98.9	111.3	104.7
Petroleum & Related Industries	99.9	104.1	104.1	111.1	108.1
Other Industrial Processes	308.0	350.9	277.6	394.6	302.8
Solvent Utilization	2.5	2.9	2.9	3.2	3.1
Storage & Transport	2.4	2.6	2.6	3.0	3.0
Waste Disposal & Recycling	20.7	23.5	20.4	26.9	22.9
TOTAL	2,849.7	3,173.3	2,060.4	3,577.9	2,184.5
CO					
Fuel Comb. Industrial	529.1	586.8	586.8	656.7	656.7
Fuel Comb. Other	96.8	118.4	118.4	140.1	140.1
Chemical & Allied Product Mfg	1,923.4	1,957.2	1,957.2	2,233.0	2,233.0
Metals Processing	2,106.3	2,418.1	2,418.1	2,486.1	2,486.1
Petroleum & Related Industries	436.3	475.1	475.1	545.9	545.9
Other Industrial Processes	754.0	947.1	947.1	1,134.1	1,134.1
Solvent Utilization	2.5	2.8	2.8	3.2	3.2
Storage & Transport	54.8	51.5	51.5	58.7	58.7
Waste Disposal & Recycling	96.7	106.8	106.8	118.7	118.7
TOTAL	5,999.7	6,663.9	6,663.9	7,376.6	7,376.6

Pollutant/Source Category	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
SO_2					
Fuel Comb. Industrial	2,482.2	2,861.9	2,861.9	3,262.0	3,262.0
Fuel Comb. Other	202.4	243.7	243.7	282.9	282.9
Chemical & Allied Product Mfg	440.1	486.6	486.6	546.4	546.4
Metals Processing	664.7	808.9	808.9	857.1	857.1
Petroleum & Related Industries	434.8	449.5	449.5	489.3	489.3
Other Industrial Processes	393.6	456.4	456.4	522.6	522.6
Solvent Utilization	0.8	0.9	0.9	1.0	1.0
Storage & Transport	4.6	5.4	5.4	6.4	6.4
Waste Disposal & Recycling	21.0	22.8	22.8	26.1	26.1
TOTAL	4,644.2	5,336.2	5,336.2	5,993.9	5,993.9
PM_{10}					
Fuel Comb. Industrial	221.1	245.2	245.2	275.8	275.8
Fuel Comb. Other	16.6	19.8	19.8	23.0	23.0
Chemical & Allied Product Mfg	62.5	65.4	65.4	74.2	74.2
Metals Processing	137.9	167.2	167.2	179.4	179.4
Petroleum & Related Industries	28.9	31.7	31.7	36.0	36.0
Other Industrial Processes	374.3	427.3	427.3	485.5	485.5
Solvent Utilization	2.1	2.6	2.6	3.0	3.0
Storage & Transport	64.4	73.8	73.8	83.6	83.6
Waste Disposal & Recycling	8.0	8.7	8.7	9.7	9.7
Miscellaneous	10.7	13.7	13.7	16.9	16.9
TOTAL	926.4	1,055.3	1,055.3	1,186.9	1,186.9
$PM_{2.5}$					
Fuel Comb. Industrial	162.0	178.1	178.1	200.0	200.0
Fuel Comb. Other	8.2	9.7	9.7	11.1	11.1
Chemical & Allied Product Mfg	42.7	45.7	45.7	52.0	52.0
Metals Processing	96.3	116.7	116.7	124.4	124.4
Petroleum & Related Industries	19.5	21.3	21.3	24.1	24.1
Other Industrial Processes	224.3	257.9	257.9	294.7	294.7
Solvent Utilization	1.8	2.2	2.2	2.5	2.5
Storage & Transport	26.5	30.5	30.5	34.4	34.4
Waste Disposal & Recycling	6.7	7.2	7.2	8.0	8.0
Miscellaneous	1.6	2.1	2.1	2.6	2.6
TOTAL	589.5	671.5	671.5	754.0	754.0

Pollutant/Source Category	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
NH_3					
Fuel Comb. Industrial	10.0	10.3	10.3	11.3	11.3
Fuel Comb. Other	0.3	0.3	0.3	0.3	0.3
Chemical & Allied Product Mfg	182.6	202.6	202.6	231.6	231.6
Metals Processing	5.9	6.8	6.8	7.0	7.0
Petroleum & Related Industries	42.8	48.7	48.7	55.1	55.1
Other Industrial Processes	2.1	2.1	2.1	2.1	2.1
TOTAL	243.6	270.8	270.8	307.5	307.5

* The totals reflect emissions for the 48 contiguous States, excluding Alaska and Hawaii. Totals may not add due to rounding.

Utilities

EPA used the IPM to estimate future year heat input, SO_2 and NO_x emissions, fuel type, and optimal control techniques for each current and planned electric utility unit.[5] The IPM modeling inputs, outputs, and key assumptions are discussed in more detail in EPA 1997b. This section focuses on the steps used to supplement these projections by adding emissions of VOC, CO, PM_{10}, $PM_{2.5}$, and NH_3, as well as adding data elements needed for air quality modeling (location and stack parameters).

Overview of Approach

For the prospective analysis, EPA matched each unit in the IPM file to the 1990 NPI (Pechan, 1994c; Pechan, 1995a) based on the Office of the Regulatory Information System (ORIS) plant and boiler code. For units that were matched, stack parameters and location coordinates were taken directly from the NPI. VOC, CO, PM_{10}, and $PM_{2.5}$ emissions were calculated using AP-42 emission rates (standard EPA emission factors that are developed from stack tests and engineering calculations) and control efficiencies as reported in the NPI. NH_3 emissions were calculated for ammonia slippage where boilers were forecast to install selective catalytic reduction (SCR) as the control technique to reduce NO_x emissions.

Base Year Emissions

The base year emission inventory used in the air quality modeling portion of the Section 812 prospective analysis is Version 3 of the NPI. The utility portion of this inventory, which covers fossil-fuel fired steam electric generating boilers, was developed from DOE Form EIA-767 (the Steam-Electric Plant Operation and Design Report) fuel use data combined with AP-42 emission factors and emission limits from EIA-767. The NPI also includes gas turbines and internal combustion engines to the extent that these were included in the 1985 NAPAP.

The IPM uses a different modeling set as input for emission projections. This set is consistent with the NPI in that boilers included in the NPI are also in the IPM modeling set. The IPM data set, however, also includes combustion turbines (more than those included in the NPI) and non-utility generators. Some of these units may be included in the NPI as part of the industrial point source inventory or area source fuel combustion (and would thus be double-counted in the projections) while others may be missing from the NPI data set. It should be noted that in projection year 2000, under the Pre-CAAA scenario, these units account for just over 1 percent of total utility NO_x emissions and only 0.1 percent of total utility SO_2 emissions. Therefore, the potential exclusion of the units from the 1990 base year data set and the potential double-counting in the projection year is expected to have minimal effect on air quality, benefits, and cost modeling.

[5] The IPM was constructed and is maintained by ICF, an EPA contractor.

Control Scenarios

The Pre-CAAA and Post-CAAA scenario NO_x and SO_2 emissions were modeled using IPM (EPA, 1997b). Heat input by unit under each projection year and scenario was also derived from IPM results. Default emission factors were applied to the unit-specific heat input to calculate VOC, CO, PM_{10}, and $PM_{2.5}$ emissions. For these pollutants, the Pre-CAAA and Post-CAAA emission rates were assumed to be the same. Any differences in emissions between these scenarios are due to shifts in operation between units or fuel changes (including ash content of the coals as well as switching to natural gas) predicted by IPM. Differences in NH_3 emissions between the scenarios is a fraction of added SCR controls to reduce NO_x under the Post-CAAA scenario.

Emission Summary

Table A-7 is a summary of utility emissions by unit and fuel type. Oil- and gas-fired units have been grouped together, because information on the division of fuel for boilers burning oil and gas was not contained in the unit-level file developed from IPM. Utility SO_2 and NO_x emissions are affected most by the CAAA. Differences between Pre-CAAA and Post-CAAA NO_x emissions result from a combination of Title IV - Acid Rain regulations, and nonattainment provisions that require NO_x RACT controls for major stationary sources in ozone NAAs. The anticipated effect of the OTC MOU and a regional NO_x trading program on stationary source NO_x emissions in the eastern portion of the United States also influence the Post-CAAA utility NO_x emissions estimates (OTC, 1994). In 2010, the difference between Pre-CAAA and Post-CAAA utility NO_x is about 5 million tons.

SO_2 emission reductions attributable to the CAA is the result of the Title IV - Acid Rain control program. Through this program, annual emissions of SO_2 are to be reduced by 10 million tons from 1980 levels through a market-based allowance system. Differences between Pre-CAAA and Post-CAAA SO_2 estimates for coal-fired units reflect flue gas desulfurization installations and some switching to lower sulfur coal in the Post-CAAA case. SO_2 emissions from oil/gas units are actually lower in the Pre-CAAA scenario because a higher percentage of units would have been expected to burn coal with less stringent air pollution emission limits. The 2010 Pre-CAAA estimates show no significant oil use by utilities.

Table A-7
Utility Emission Summary*
(thousand tons per year)

Pollutant/Source Category		1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
VOC						
	Coal	27.1	23.6	23.1	26.3	24.7
	Gas/Oil/Other	7.8	1.8	1.9	1.5	1.7
	Internal Combustion	1.9	5.6	6.1	21.2	23.5
	TOTAL	36.8	31.0	31.1	49.0	49.9
NO_x						
	Coal	6,689.5	7,895.7	3,779.0	8,700.3	3,610.0
	Gas/Oil/Other	679.1	324.1	216.0	220.0	72.6
	Internal Combustion	57.1	97.3	82.1	134.4	83.7
	TOTAL	7,425.7	8,317.1	4,077.1	9,054.7	3,766.3
CO						
	Coal	232.6	191.8	188.7	215.3	202.5
	Gas/Oil/Other	81.9	48.0	49.3	44.8	45.9
	Internal Combustion	14.7	50.7	55.4	193.6	214.8
	TOTAL	329.2	290.5	293.4	453.7	463.2
SO_2						
	Coal	15,221.9	16,111.3	10,315.0	17,696.0	9,776.6
	Gas/Oil/Other	611.9	44.1	175.5	0.0	84.2
	Internal Combustion	30.7	0.0	0.0	0.0	0.0
	TOTAL	15,897.5	16,155.4	10,490.5	17,696.0	9,860.8
PM_{10}						
	Coal	268.4	244.7	245.1	281.1	249.0
	Gas/Oil/Other	10.6	1.5	2.5	1.0	1.6
	Internal Combustion	4.1	6.1	6.6	23.4	26.0
	TOTAL	283.1	252.3	254.2	305.5	276.6
$PM_{2.5}$						
	Coal	99.2	82.9	82.3	97.0	83.7
	Gas/Oil/Other	5.9	1.3	2.4	1.0	1.6
	Internal Combustion	3.7	6.0	6.6	23.3	25.8
	TOTAL	108.8	90.2	91.3	121.3	111.1
NH_3						
	Coal	0.0	0.0	33.3	0.0	221.9
	Gas/Oil/Other	0.0	0.0	0.0	0.0	0.0
	Internal Combustion	0.0	0.0	0.0	0.0	0.0
	TOTAL	0.0	0.0	33.3	0.0	221.9

* The totals reflect emissions for the 48 contiguous States, excluding Alaska and Hawaii.

Nonroad Engines/Vehicles

The nonroad engines/vehicles sector includes all transportation sources that are not counted as highway vehicles. Thus, this sector includes marine vessels, railroads, aircraft, and nonroad internal combustion engines and vehicles. Nonroad engines are significant emitters of NO_x, PM_{10}, and VOC. Diesel engines account for most of the NO_x and PM_{10} emissions, while gasoline engines emit most of the VOC. This section contains summaries of 1990 emissions from major source categories in the nonroad engine/vehicle sector. The growth factors and control efficiencies used to project emissions to 2000 and 2010 under the two control scenarios are also described.

Overview of Approach

Nonroad VOC and NO_x emissions were projected using ERCAM; similar modeling techniques were used for the remaining pollutants. The algorithm for projecting nonroad emissions is:

$$EMIS_Y = EMIS_{90} * GFAC_Y * \left[1 - CE_Y * PE_Y\right]$$

where:

$EMIS_Y$	=	emissions in projection year y
$EMIS_{90}$	=	1990 emissions
GFAC	=	growth factor for projection year y
CE_Y	=	control efficiency for projection year y
PE_Y	=	penetration rate for projection year y

The control efficiency is a function of the percentage reduction or decrease in emission rate expected through new engine standards and the fraction of emissions covered through fleet turnover. The penetration rate accounts for the fraction of emissions from affected engine types (generally resulting from horsepower (hp) cutoffs) in a broad engine category (e.g., construction).

Growth factors applied are based on the 1995 BEA GSP projections by State and industry and population projections. The 1990 base year emissions are from Version 3 of the NPI. Under the Pre-CAAA scenario, no changes in engine standards are modeled (future year emission rates are assumed to be equivalent to 1990 rates). Under the Post-CAAA scenario, Federal nonroad engine standards are incorporated. All modeling is at the county and SCC level to retain necessary details for cost and air quality modeling.

Base Year Emissions

The 1990 emission estimates for nonroad vehicles are from the 1990 NPI. The emissions in the NPI from sources in the nonroad engines/vehicles sector are based on one of the following sources: (1) a nonroad emission inventory compiled by EPA's OMS (EPA, 1991b); or (2) the 1985 NAPAP Area Source Emissions Inventory. EPA's OMS inventories provided the majority of criteria pollutant emissions for the base year 1990 inventory, accounting for nearly 90 percent of VOC emissions and nearly 60 percent of NO_x emissions. The remaining emissions for the nonroad engines/vehicles sector are based on the NAPAP emissions inventory.

Growth Projections

The 1990 estimates from the NPI for the nonroad engine/vehicle sector are projected to 2000 and 2010 to estimate the impact of CAAA controls on future year emission levels. For each major nonroad engine/vehicle category a growth surrogate is identified for estimating future emissions. Growth surrogates for nonroad engine/vehicle categories include 1995 BEA projections of population for recreational and lawn and garden equipment categories, and an appropriate GSP by SIC code estimate for all other categories. SIC codes are assigned to area source categories according to an assignment made for other EPA projects, such as the ozone and PM NAAQS cost analyses. This assignment of nonroad engine/vehicle categories to BEA indicators is shown in Table A-8.

The 1995 BEA GSP and population projections by State and industry were selected as the best available growth factors for projecting 1990 emissions to 2000 and 2010 for the prospective analysis (BEA, 1995). EPA's projection guidance recommends that area source emissions be projected using surrogate growth indicators such as BEA, or using local studies/surveys (EPA, 1991a). BEA provided a consistent set of projections by SIC code that could be easily applied to the 1990 nonroad engine/vehicle sector across all geographic regions.

Control Scenarios

Emissions from engines used in nonroad equipment are a significant source of NO_x, VOC, and PM emissions. In some areas of the country, emissions from nonroad engines represent a third of the total mobile source NO_x and VOC emissions and over two-thirds of the mobile source PM emissions.

Pre-CAAA Scenario

The Pre-CAAA scenario incorporates the growth factors described above, and assumes that future year emission rates from nonroad engines remain the same as 1990 levels.

Table A-8
BEA Growth Forecasts by Major Source Category:
Nonroad Engines/Vehicles

		Annual Growth (% per year):	
Major Category	**BEA Growth Category***	**1990-2000**	**1990-2010**
Nonroad Internal Combustion Engines and Vehicles:			
Airport Service Equipment	Transportation by air (SIC 45)	5.8%	5.5%
Construction Equipment	Construction (SIC 15, 16, and 17)	0.8%	1.0%
Farm Equipment	Farm (SIC 01)	2.4%	2.4%
Industrial Equipment	Total Manufacturing	1.9%	1.9%
Lawn & Garden Equipment	Population	1.1%	1.0%
Light Commercial Equipment	Total Manufacturing	1.9%	1.9%
Logging Equipment	Agricultural Services, Forestry, Fisheries (SIC 07, 08, 09)	7.8%	7.4%
Recreational Marine Vessels	Population	1.1%	1.0%
Recreational Vehicles	Population	1.1%	1.0%
Aircraft:			
Military	Federal, military	-1.2%	-0.4%
Commercial	Transportation by air (SIC 45)	5.8%	5.5%
Civil	Transportation by air (SIC 45)	5.8%	5.5%
Railroads	Railroad Transportation (SIC 40): Earnings	-1.5%	-0.9%
Commercial Marine Vessels	Water Transportation (SIC 44)	-0.5%	-0.2%

*BEA growth category refers to GSP projections for each industry, unless otherwise specified.

Post-CAAA Scenario

The CAAA specifically directed EPA to study the contribution of nonroad engines to urban air pollution, and to regulate them, if warranted. In 1991, EPA released a study that documented higher than expected emission levels across a broad spectrum of nonroad engines and equipment (EPA, 1991b). In response, EPA initiated several regulatory programs for nonroad engines. The impact of these programs is incorporated in the Post-CAAA scenario.

Emission Summary

A summary of projected emissions by engine classification is shown in Table A-9. Future year VOC and NO_x emissions are the pollutants most affected by the CAAA, as most of the new engine standards focus on controlling these ozone precursors. CO, SO_2, and PM_{10} emissions under the Pre-CAAA scenario are nearly equal to emissions under the Post-CAAA scenario since CAAA controls only affect NO_x and VOC emissions from the nonroad engine/vehicle sector. Effects in 2000 are modest because the new engine standards do not affect emissions until the mid-to-late 1990s. More dramatic differences are seen in 2010.

Gasoline-powered engines are the most significant nonroad VOC emitter, so most of the VOC emissions difference in this sector is the result of small spark ignition (SI) engine standards. Lawnmowers, for example, are affected by these new standards.

NO_x emission benefits shown in Table A-9 for non-road engines result principally from compression ignition (CI) (diesel engine) standards. In 2010, difference between the Post-CAAA and Pre-CAAA nonroad diesel engine NO_x emissions is almost 0.5 million tons. These engines are primarily used in construction equipment. Other off-highway NO_x sources with lower emissions levels under the Post-CAAA scenario include railroads (diesel locomotives) and marine vessels. In contrast, a small NO_x disbenefit is associated with non-road gasoline engines in the Post-CAAA scenario; this is because the small SI engine standard for hydrocarbons (HCs) is expected to increase NO_x emissions.

Table A-9
Nonroad National Emission Projections by Source Category*
(thousand tons per year)

Pollutant/Source Category		1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
VOC						
	Nonroad Gasoline	1,596.8	1,810.8	1,549.3	2,004.0	1,257.4
	Nonroad Diesel	185.0	225.3	225.3	261.6	261.6
	Aircraft	191.9	242.6	242.6	300.3	300.3
	Marine Vessels	36.0	33.6	33.6	34.4	34.4
	Railroads	44.2	37.2	37.2	35.5	35.4
	TOTAL	2,053.9	2,349.5	2,088.0	2,635.8	1,889.2
NO_x						
	Nonroad Gasoline	176.0	205.4	220.5	237.0	269.8
	Nonroad Diesel	1,438.4	1,751.4	1,603.0	2,032.5	1,546.9
	Aircraft	139.7	194.8	194.8	249.2	249.2
	Marine Vessels	183.7	169.8	169.8	173.2	161.5
	Railroads	898.0	759.4	759.4	725.9	513.6
	TOTAL	2,835.8	3,080.9	2,947.5	3,417.8	2,740.9
CO						
	Nonroad Gasoline	12,047.2	13,973.8	13,417.5	15,735.4	15,020.6
	Nonroad Diesel	781.9	948.6	948.6	1,097.3	1,097.3
	Aircraft	960.9	1,423.6	1,423.7	1,855.9	1,855.9
	Marine Vessels	58.0	54.1	54.1	55.5	55.5
	Railroads	121.8	102.8	102.8	98.2	98.2
	TOTAL	13,969.8	16,503.0	15,946.6	18,842.3	18,127.5
SO_2						
	Nonroad Gasoline	3.2	3.6	3.6	4.1	4.1
	Nonroad Diesel	16.7	19.0	19.0	22.4	22.4
	Aircraft	8.0	10.9	10.9	13.8	13.8
	Marine Vessels	147.5	139.8	139.8	142.3	142.3
	Railroads	66.6	56.3	56.3	53.8	53.8
	TOTAL	242.1	229.6	229.6	236.5	236.5
PM_{10}						
	Nonroad Gasoline	42.1	47.0	47.0	51.6	51.6
	Nonroad Diesel	185.6	227.3	227.3	262.6	187.1
	Aircraft	40.4	38.1	38.1	41.3	41.3
	Marine Vessels	24.2	22.7	22.7	23.3	23.3
	Railroads	44.0	37.3	37.3	35.7	33.1
	TOTAL	336.3	372.5	372.5	414.4	336.3

Pollutant/Source Category	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
$PM_{2.5}$					
Nonroad Gasoline	35.0	39.2	39.2	42.9	42.9
Nonroad Diesel	170.8	209.1	209.1	241.6	172.1
Aircraft	28.5	26.9	26.9	29.1	29.1
Marine Vessels	17.8	16.6	16.6	17.0	17.0
Railroads	40.5	34.3	34.3	32.8	30.4
TOTAL	292.6	326.1	326.1	363.5	291.7
NH_3					
Nonroad Gasoline	0.0	0.0	0.0	0.0	0.0
Nonroad Diesel	0.0	0.0	0.0	0.0	0.0
Aircraft	0.0	0.0	0.0	0.0	0.0
Marine Vessels	1.1	1.1	1.1	1.1	1.1
Railroads	1.8	1.5	1.5	1.4	1.4
TOTAL	2.9	2.6	2.6	2.5	2.5

* The totals reflect emissions for the 48 contiguous States, excluding Alaska and Hawaii.

Motor Vehicles

Motor vehicles are a significant contributor of VOC, NO_x, and CO emissions. In 1990, motor vehicles contributed 30 percent of total VOC, 33 percent of total NO_x, and 66 percent of total CO emissions. The CAA includes provisions to reduce motor vehicles emissions in both Title I and Title II.

Overview of Approach

The general procedure for calculating historic and projection year motor vehicle emissions is to multiply activity, in the form of VMT by pollutant specific emission factor estimates. ERCAM (Pechan, 1996) was used to project motor vehicle emissions for VOC, NO_x, and CO. Emission factors for these pollutants were generated using the EPA's motor vehicle emission factor model MOBILE5a (EPA, 1993a). PM_{10}, $PM_{2.5}$, and SO_2 emission factors were generated using another EPA motor vehicle emission factor model, PART5 (EPA, 1994). Emission factors for all pollutants are modeled using common assumptions about ambient temperatures and vehicle speeds at the State level. Control programs (I/M, reformulated gasoline) are specified at the county level. Temporally, emissions are calculated by month and summed to develop annual emission estimates.

Base Year Emissions

Base year emissions are from Version 3 of the NPI. The NPI VMT, by county/SCC (i.e., vehicle type/functional roadway class), are based on data from the Federal Highway Administration (FHWA) Highway Performance Monitoring System (HPMS). The HPMS area wide data base contains State-level VMT estimates for rural and small urban areas, as well as separate VMT estimates for each large urban area within the State. VMT estimates for each of these categories are by functional roadway class. Two procedures were performed to convert this VMT data into a county/SCC level format. First, each State's rural, small urban, and large urban VMT by functional roadway class were distributed to the county level based on population data. Second, the resulting county/functional roadway class VMT were allocated to the vehicle type level based on HPMS and other FHWA data. The resulting VMT estimates are county-level estimates segregated by vehicle type and roadway class.

The 1990 emission estimates were calculated by applying 1990 control-specific emission factors to the

VMT estimates. The 1990 emission factors were generated using historical temperatures, gasoline volatility Reid vapor pressure (RVP) data, and inspection and maintenance (I/M) information. Emissions estimates are calculated at the county/vehicle type/roadway type level, allowing for county differences in I/M programs.

Growth Projections

Vehicle Miles Traveled

The general procedure used to project motor vehicle emissions was to grow 1990 activity (VMT) to the future year (2000 or 2010) and then to apply future year emission factors. Estimates of national growth in VMT from the MOBILE4.1 Fuel Consumption Model (FCM) (EPA, 1991c; Wolcott and Kahlbaum, 1991) were used as the basis for VMT projections. Primary MOBILE4.1 FCM inputs were vehicle registrations, VMT, and fuel economy for each vehicle class. MOBILE4.1 FCM outputs included estimates of fleet fuel consumption, VMT, on-road fuel economy, and vehicle registrations. All are national values. Historical vehicle stock information is available from R.L. Polk and Department of Transportation (DOT). The MOBILE4.1 FCM relies primarily on the R.L. Polk data to estimate historical stocks of cars and light trucks in 1990, and uses DOT and American Association of Automobile Manufacturers statistics to estimate truck stocks by weight class.

Modeled Motor Vehicle Emission Rates

The tunnel study portion of the South Coast Air Quality Study (SCAQS) (Ingalls et al., 1989) showed that there were wide discrepancies between measured and modeled motor vehicle emissions in an experiment performed in 1987 at a tunnel near Los Angeles. Running VOC emission factors were from 1.4 to 6.9 times the emission factors calculated from the California Air Resources Board (CARB) computer program output, measured CO emission rates were from 1.1 to 3.6 times modeled emission factors, and measured NO_x emission rates were 0.6 to 1.4 times the modeled values. Since that time there have been many research studies performed to attempt to identify the reasons for the observed discrepancies and to modify the two models developed by regulatory agencies (EPA's MOBILE emission factor model and CARB's emission factors model (EMFAC)) to perform better in estimating real world emission rates.

It is difficult to estimate how present uncertainties in estimating motor vehicle emissions might affect the estimated difference between Pre-CAAA and Post-CAAA emissions. The difference between the scenarios will widen if the *excess* emissions are successfully reduced by Post-CAAA measures. However, if the *excess* emissions are irreducible, or not influenced by new Post-CAAA initiatives, then the relative emissions difference between the cases would be expected to remain the same as is estimated in this analysis.

Control Scenarios

This section describes the control assumptions for the Pre-CAAA and Post-CAAA scenarios. Table A-10 summarizes the geographic applicability of all controls modeled.

Pre-CAAA Scenario

The Pre-CAAA scenario applies estimated increases in activity levels with emission factors reflecting control programs in place prior to the passage of the 1990 Amendments. The motor vehicle controls applied under this scenario include the Federal Vehicle Motor Control Program (FMVCP) (tailpipe standards), Phase I gasoline volatility (RVP limits), and current 1990 I/M programs.

PM_{10} emission factors representing gasoline vehicles do not vary between the Pre-CAAA and Post-CAAA control scenarios. Pre-CAAA PM_{10} emission factors for diesel vehicles were generated by freezing emission rates at 1993 levels, since the PART5 model does not calculate emission factors without application of CAA tailpipe standards. A composite diesel emission factor by diesel vehicle type was then calculated by applying by-model-year emission rates by yearly travel fractions.

Post-CAAA Scenario

The Post-CAAA control scenario incorporates the likely effects of controls mandated under the CAAA. Motor vehicle controls applied under this scenario include CAA tailpipe standards and evaporative standards, Phase II RVP limits, reformulated gasoline, oxygenated fuel, I/M (none, basic, low enhanced, OTR low enhanced, and high enhanced), and low emission vehicles. Of the above mentioned controls, only I/M and reformulated gasoline affect particulate and SO_2 emission factors. Each of the CAA controls and their applicability are summarized in Table A-10.

Emission Summary

Table A-11 summarizes national emissions by vehicle type. Comparison of Pre- and Post-CAAA scenarios shows motor vehicle VOC emissions reductions of 28 percent in 2000 and 46 percent in 2010 as a larger fraction of the vehicle fleet meets low emission vehicle (LEV) program emission standards. CAA tailpipe standards, reformulated gasoline, and I/M requirements also contribute to declines in motor vehicle VOC emissions.

For motor vehicle-emitted NO_x, again the differences between Post-CAAA and Pre-CAAA scenarios are most pronounced in 2010 (38 percent, compared with a 14 percent difference in 2000) as the 49 State LEV program becomes more effective with fleet turnover.

The Post-CAAA scenario also shows that there are expected to be significant CO benefits achieved through the Nonattainment (Title I) and Motor Vehicle Provisions (Title II) of the 1990 Amendments. The most important new provisions and programs expected to be providing these benefits, in order of estimated importance, include: enhanced vehicle emission inspections, wintertime oxygenated fuel use, and LEV program adoption.

SO_2 motor vehicle emissions decrease under the Post-CAAA scenario as a result of sulfur limits for diesel fuel. Section 211 of the CAAA limited the sulfur content of motor vehicle diesel fuel to 0.05 percent (by weight) beginning October 1, 1993.

Motor vehicle PM_{10} and $PM_{2.5}$ emission changes result from CAA tailpipe standards. Almost all of the motor vehicle-emitted PM changes occur because of PM exhaust emission standards for heavy-duty diesel trucks (HDDTs).

Table A-10
Applicability of Mobile Source Control Programs

Control Measure	Applicability
Pre-CAAA Scenario	
FMVCP	National
Phase I RVP	National (standard varies by region)
I/M	Programs in place in 1990
Post-CAAA Scenario	
Phase II RVP	National (standard varies by region)
CAA Tailpipe Standards	National
CAA Evaporative Controls	National
Heavy Duty NO_x Standard	National
Federal Reformulated Gasoline	Nine areas required to adopt this program under the CAA plus areas
Oxygenated Fuel	All CO NAAs
Basic I/M	All moderate ozone NAAs, moderate CO NAAs, and areas with I/M in
Low Enhanced I/M	All areas previously required to implement high enhanced I/M who are
High Enhanced I/M	Serious and above ozone NAAs, in metropolitan areas in the OTR with
National LEV	Nationally, with the exception of California
California LEV	California

Table A-11
National Highway Vehicle Emissions by Vehicle Type*
(thousand tons)

	Vehicle Type	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
VOC						
	LDGV	4,207.2	3,823.6	2,692.9	4,311.9	2,263.6
	LDGT1	954.0	1,089.0	793.5	1,341.0	760.6
	LDGT2	803.5	711.4	550.4	867.1	583.0
	HDGV	466.9	291.1	228.8	279.8	142.2
	LDDV	11.6	1.4	1.4	<0.1	<0.1
	LDDT	2.8	1.0	1.0	0.4	0.4
	HDDV	313.9	367.5	227.2	469.6	151.8
	MC	50.5	42.5	37.8	49.9	44.3
	Total	6,810.5	6,327.6	4,533.1	7,319.7	3,945.9
NO_x						
	LDGV	3,406.1	3,633.6	2,873.8	4,161.6	2,402.1
	LDGT1	775.2	1,045.5	815.8	1,326.1	783.8
	LDGT2	557.8	646.6	565.1	821.6	631.6
	HDGV	333.1	333.2	324.3	392.6	296.3
	LDDV	35.9	4.0	4.0	<0.1	<0.1
	LDDT	7.4	2.5	2.5	1.0	1.0
	HDDV	2,318.4	2,135.1	2,051.7	2,359.1	1,443.0
	MC	11.6	14.1	14.1	16.5	16.5
	Total	7,445.6	7,814.6	6,651.3	9,078.6	5,574.4
CO						
	LDGV	40,073.4	36,759.0	26,920.2	40,304.6	23,711.9
	LDGT1	8,458.6	10,566.9	7,947.5	13,054.8	7,986.4
	LDGT2	6,533.4	6,867.5	5,349.4	8,457.5	6,102.3
	HDGV	5,895.0	2,921.9	2,766.0	1,807.1	1,639.3
	LDDV	29.1	3.8	3.8	<0.1	<0.1
	LDDT	5.7	2.3	2.3	1.0	1.0
	HDDV	1,300.1	1,827.2	1,826.8	2,397.1	2,208.3
	MC	185.6	220.8	209.5	259.3	245.9
	Total	62,480.9	59,169.6	45,025.5	66,281.6	41,895.1
SO_2						
	LDGV	143.0	151.6	151.6	178.0	178.0
	LDGT1	37.6	50.1	50.1	64.0	64.0
	LDGT2	20.5	25.6	25.6	32.6	32.6
	HDGV	10.8	11.7	11.7	14.1	14.1
	LDDV	12.7	1.1	0.3	<0.1	<0.1
	LDDT	2.8	0.8	0.2	0.3	0.1
	HDDV	340.1	390.3	97.6	480.3	120.1
	MC	0.3	0.4	0.4	0.5	0.5
	Total	567.7	631.6	337.4	769.6	409.2

	Vehicle Type	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
PM_{10}						
	LDGV	63.1	66.1	66.1	75.3	75.3
	LDGT1	15.2	18.4	18.4	23.0	23.0
	LDGT2	16.9	10.7	10.7	11.5	11.5
	HDGV	10.6	8.0	8.0	6.6	6.6
	LDDV	8.8	0.6	0.6	<0.1	<0.1
	LDDT	1.7	0.6	0.4	0.2	0.1
	HDDV	238.2	186.9	152.9	179.8	88.4
	MC	0.4	0.4	0.4	0.5	0.5
	Total	354.7	291.7	257.6	297.0	205.4
$PM_{2.5}$						
	LDGV	38.1	36.9	36.9	43.4	43.4
	LDGT1	9.8	11.2	11.2	13.8	13.8
	LDGT2	11.1	6.7	6.7	7.0	7.0
	HDGV	7.0	5.3	5.3	4.3	4.3
	LDDV	7.8	0.5	0.5	<0.1	<0.1
	LDDT	1.5	0.5	0.3	0.2	0.1
	HDDV	215.7	164.4	134.4	164.7	73.9
	MC	0.2	0.2	0.2	0.3	0.2
	Total	291.0	225.7	195.6	233.7	142.7
NH_3						
	LDGV	165.6	262.8	262.8	314.0	314.0
	LDGT1	23.6	58.5	58.5	80.6	80.6
	LDGT2	8.6	25.8	25.8	36.8	36.8
	HDGV	0.4	1.6	1.6	2.9	2.9
	LDDV	<0.1	<0.1	<0.1	<0.1	<0.1
	LDDT	<0.1	<0.1	<0.1	<0.1	<0.1
	HDDV	0.2	0.4	0.4	0.5	0.5
	MC	<0.1	<0.1	<0.1	0.1	0.1
	Total	198.5	349.2	349.2	434.9	434.9

*The totals reflect emissions for the 48 contiguous States, excluding Alaska and Hawaii. Totals may not add due to rounding.

Area Sources

This section discusses the base year 1990 area source inventory, and the development of the future year emission estimates for area sources. Area sources include small stationary sources not included in the point source data base (e.g., dry cleaners, graphic arts, industrial fuel combustion, gasoline marketing) and solvent use (e.g., consumer solvents, architectural coatings). The growth factors and control efficiencies used to project the base year 1990 area source inventory to 2000 and 2010 under the two control scenarios are also described, and alternative growth indicators for area sources are identified. ERCAM was used to project area source VOC and NO_x emissions under the two control scenarios. The approach used in ERCAM was also used to project controlled area source CO, SO_2, $PM_{2.5}$, and PM_{10} emissions.

Overview of Approach

The base year 1990 area source inventory was projected to 2000 and 2010 to estimate the combined effects of growth and CAA controls on area sources. In order to project emissions, a surrogate activity indicator (e.g., population, gasoline consumption) was identified for each area source category. In its guidance for projecting emissions for area sources, EPA identifies preferred growth indicators for each area source category (EPA, 1991a). Pechan chose a growth indicator for each area source category based on EPA's guidance, the availability of projection data in the relevant years of analysis, and the appropriateness of the measure for projecting emissions. Emissions were then projected using growth factors calculated based on projections for each activity indicator. The growth rates represent an increase or decrease in the basic activity that causes emissions.

Area source emissions for VOC and NO_x under each control scenario were projected using ERCAM; similar modeling techniques were used for the other criteria pollutants. The algorithm for projecting area source emissions is:

$$EMIS_Y = EMIS_{90} * GFAC_Y * \left[\frac{1 - (CE_Y * RE_Y)}{1 - (CE_{90} * RE_{90})}\right]$$

where:

$EMIS_Y$	=	emissions in projection year y
$EMIS_{90}$	=	1990 emissions
$GFAC_Y$	=	growth factor for projection year y
CE_Y	=	control efficiency in projection year y
RE_Y	=	rule effectiveness (RE) for the control in projection year y
CE_{90}	=	1990 control efficiency
RE_{90}	=	1990 RE

In cases where the control level for the projection year control strategy is less than the control level in 1990, 1990 control levels are retained in the projection year. All computations and reporting are at the county/SCC level for air quality and cost modeling.

Under the Pre-CAAA scenario, future year control levels are assumed to be equivalent to 1990 levels. The Post-CAAA scenario applies control levels to model the effects of the Title I nonattainment provisions, Federal rules, and, in the case of VOC, Title III MACT standards.

Base Year Emissions

The base year 1990 area source emission inventory for the prospective analysis is Version 3 of the NPI (Pechan, 1995a; Pechan, 1995b). This inventory contains county/SCC level emissions for area source categories. Most non-fugitive dust area source emissions estimates in the NPI originate with the 1985 NAPAP Area Source Emission Inventory. Exceptions to this are solvent emissions, prescribed burning, forest wildfires, fugitive dust, and residential wood combustion.

The general method for estimating 1990 area source emissions using the 1985 NAPAP Inventory was to apply growth factors to the NAPAP Inventory values. BEA historical earnings data, population, fuel

use from State Energy Data System (SEDS) (DOE, 1991), and other category-specific indicators were used to project the 1985 NAPAP to 1990. SEDS data were used as an indicator of emissions growth for the area source fuel combustion categories and for the gasoline marketing categories (EPA, 1993b). Particle size multipliers were applied to estimate PM_{10} emissions from TSP estimates (EPA, 1995).

Solvent emissions were estimated from a national solvent material balance using solvent data from various marketing surveys (EPA, 1993b). Emissions are allocated to the county-level based on employment and population data.

Prescribed burning emission estimates were based on a 1989 United States Department of Agriculture (USDA) Forest Service Inventory of PM and air toxics (USDA, 1989). This inventory of prescribed burning contained State-level emissions, which were allocated to the county level using the State-to-county distribution of emissions in the 1985 NAPAP Inventory.

Wildfire emissions were taken from estimates developed for the GCVTC for the 11 GCVTC States (Western U.S.) (Radian, 1995). The wildfire data in the GCVTC Inventory represent a detailed survey of forest fires in the study area. For non-GCVTC States, emissions are based on the 1985 NAPAP Inventory values.

PM_{10} emissions for *fugitive dust* sources were taken from the Trends inventory (EPA, 1997a) for agricultural tilling, agricultural burning, construction activity, paved roads, unpaved roads, prescribed burning, and wind erosion. Emissions from beef cattle feedlots were developed for the NPI. In general, the Trends Inventory emission estimates are available at the State level, with the exception of construction activity emission estimates, which are at the EPA-region level. These were disaggregated to the county level based on Census of Agriculture data, land use, and construction earnings data. Paved and unpaved road emissions are estimated using the EPA's OMS PART5 emission factor model combined with paved and unpaved road VMT estimates based on FHWA data. PART 5 reentrained road dust emission factors depend on the average weight, speed, and number of wheels of the vehicles traveling on paved and unpaved roadways, the silt content of roadway surface material, and precipitation data. The activity factor for calculating reentrained road dust emissions is VMT.

Residential wood combustion emissions estimated for EPA's NET effort were used in Version 3 of the NPI (EPA, 1993c). Residential wood combustion emissions include those from traditional masonry fireplaces, freestanding fireplaces, wood stoves, and furnaces.

For the States of California and Oregon, 1990 criteria pollutant emissions from the GCVTC inventory were incorporated for all area source categories. The data for these two States are based on State-compiled inventories that are presumably based on more recent and detailed data than the emissions in the NAPAP Inventory.

Growth Projections

The base year 1990 area source inventory was projected to 2000 and 2010 to determine the effects of CAA controls on future emission levels. Growth in pollution generating activity to future years was estimated using the BEA industry GSP and population projections for most area source categories. Exceptions include activity indicators for agricultural tilling and burning and managed (or prescribed) burning. For example, the USDA has developed baseline projections of farm acres planted (USDA, 1998). These data, combined with historical data back to 1990, for eight major crop types shows an average annual growth of only 0.38 percent per year from 1990 to 2007. The BEA GSP projections for *farm* result in an annual average growth of 2.0 percent per year. Projections of acres planted represent better predictors of future activity than GSP for agricultural tilling, so they were used in this projection.

EPA's projection guidance states that area source projections can be made using local studies or surveys,

or through surrogate growth indicators such as BEA. Because this is a national projection, BEA was chosen as a consistent data set which could be used across all regions. Emissions must be allocated to the grid cell in order to perform air quality modeling; these projections will not reflect changes in the spatial patterns of emissions between counties or grid cells, since State-level growth surrogates are used. Essentially, BEA GSP projections incorporate inputs to production, and therefore, reflect future changes in technology, processes, and efficiency. Ideally, projections from States and Metropolitan Planning Organizations would be a more reliable estimate of growth in population, land use, and employment, but these were not available in a consistent format for the entire contiguous United States.

Control Scenarios

The Pre-CAAA scenario for area source emissions assumes that future year control levels are equal to those in 1990 with the exception of applying the new source performance standards (NSPS) for residential woodstoves. The residential woodstove NSPS affects emissions of both PM and VOC in all areas. The Post-CAAA scenario applies future year controls to model the impact of the 1990 Amendments on projected emissions.

Changes in agricultural practices are likely to influence future fugitive dust emissions from activities like agricultural tilling. In recent years, agricultural practices such as conservation tillage have been instituted to provide protection against surface soil erosion, primarily from water and runoff losses. These practices have also affected wind erosion losses. The primary attributes of conservation tillage practices are: (1) reducing the number of passes by farm vehicles; and (2) maintaining a higher amount of crop residue in the soil. With respect to particle emissions from tilling operations, the reduced number of vehicle passes through the field is the most important parameter. The emission rate (using current EPA estimation methods) is primarily related to the acres tilled (and therefore, the number of vehicle passes) and the soil silt content. Assuming the soil silt content remains the same, reducing the number of vehicle passes produces a proportional reduction in emissions. The increased crop residue provided by conservation tillage acts to help shelter the soil particles from wind erosion, which reduces soil depletion and reduces vertical fluxes of particles to the atmosphere. The increased residue has little, if any, effect on emissions.

Projections of conservation tillage practices are that the amount of conservation tillage in 2000 will be 26 percent of total acres tilled. The 26 percent figure is the level achieved in 1990. The 2010 projection assumes that conservation tillage increases to 50 percent by 2010. Because the trend toward conservation tillage appears to result from the 1985 Farm Bill conservation compliance program, economic influences, and improved efficiency, the same assumptions are used for estimating Pre- and Post-CAAA PM_{10} and $PM_{2.5}$ emissions for this category.

Under the Post-CAAA scenario, controls are implemented in PM NAAs. The controls modeled depend on the severity of PM nonattainment and the level of emissions from source categories for which controls are available. The Post-CAAA projection for NO_x incorporates controls for industrial fuel combustion emissions to model the effects of lowering the RACT source size cutoff in ozone NAAs. Low NO_x burners were selected as the representative NO_x control. CAA controls affecting VOC include controls for Title I (RACT, new CTGs, stage II vapor recovery, and Federal consumer solvent controls), Title III MACT standards, and onboard vapor recovery systems. The same control level is applied in 2000 and 2010. Future year control levels for SO_2 and CO area source emitters (generally fuel combustion and fires) were assumed to be equivalent to 1990 levels under both the Pre-CAAA and Post-CAAA scenario.

Emission Summary

Table A-12 is a summary of emission projections by year and scenario at the Tier 2 source category level.

The VOC emission differences between Post-CAAA and Pre-CAAA scenarios shown in Table A-12 for 2000 and 2010 are largely expected to result from Federal measures and ozone NAA-specific requirements to reduce ozone precursor emissions. Area source categories with the biggest differences between Post-CAAA and Pre-CAAA VOC emissions include commercial and consumer solvent use, surface coating (paints), small graphic arts shops, and hazardous waste treatment, storage, and disposal facilities (TSDFs). Note that while many hazardous waste TSDFs are large enough emitters to be classified as point sources, they are represented in the NPI as area sources. Service station VOC emissions are reduced in 2000 primarily by Stage II vapor recovery systems installed in NAAs, with further reductions in refueling emissions expected by 2010 as onboard vapor recovery systems are installed in new cars and light trucks.

Only modest NO_x emission benefits are expected from CAA mandates for area sources, as most CAA initiatives focus on major stationary sources. Some NO_x reducing measures, however, do affect the area source category; some controls are required in serious, severe, and extreme ozone NAAs emitting 25 tons per year, or less. In addition, some sources emitting 25 to 100 tons of NO_x per year are represented in the area source emissions file. Area source PM_{10} emitters with differences between the Post-CAAA and Pre-CAAA scenarios are fugitive dust sources.

Table A-12
Area Source Emission Summary by Pollutant For 1990, 2000, and 2010*
(thousand tons)

Pollutant/Source Category	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
VOC					
Fuel Comb. Industrial	17.8	22.4	22.4	26.6	26.6
Fuel Comb. Other	686.0	623.6	623.6	518.2	518.2
Chemical & Allied Product Mfg	449.2	517.0	366.3	578.5	408.5
Petroleum & Related Industries	450.2	454.8	198.5	494.5	207.7
Other Industrial Processes	84.4	94.8	93.1	108.0	106.2
Solvent Utilization	4,701.0	5,459.2	4,290.7	6,146.6	4,780.6
Storage & Transport	1,220.3	1,537.8	1,328.8	1,744.6	1,298.1
Waste Disposal & Recycling	2,154.6	2,596.5	471.3	3,030.2	524.2
Natural Sources	13.8	13.8	13.8	13.8	13.8
Miscellaneous	568.6	621.6	584.9	656.8	656.8
TOTAL	10,345.9	11,941.7	7,993.5	13,317.7	8,540.6
NO_x					
Fuel Comb. Industrial	1,269.7	1,615.6	1,600.2	1,917.8	1,900.1
Fuel Comb. Other	611.2	702.7	702.7	797.7	797.7
Petroleum & Related Industries	19.4	15.8	15.8	15.0	15.0
Other Industrial Processes	4.3	5.2	5.2	6.0	6.0
Waste Disposal & Recycling	60.0	67.3	67.3	74.5	74.5
Miscellaneous	224.1	228.1	228.1	230.7	230.7
TOTAL	2,188.8	2,634.8	2,619.4	3,041.7	3,023.9
CO					
Fuel Comb. Industrial	192.6	244.3	244.3	289.5	289.5
Fuel Comb. Other	3,759.1	4,674.4	4,674.4	5,485.9	5,485.9
Petroleum & Related Industries	3.9	3.2	3.2	3.0	3.0
Other Industrial Processes	2.0	2.7	2.7	3.1	3.1
Waste Disposal & Recycling	1,401.9	1,542.9	1,542.9	1,672.8	1,672.8
Miscellaneous	6,246.0	6,477.6	6,477.6	6,625.6	6,625.6
TOTAL	11,605.5	12,945.0	12,945.0	14,080.0	14,080.0
SO_2					
Fuel Comb. Industrial	626.9	803.6	803.6	948.4	948.4
Fuel Comb. Other	390.6	463.8	463.8	541.5	541.5
Petroleum & Related Industries	1.4	1.2	1.2	1.1	1.1
Other Industrial Processes	1.7	2.2	2.2	2.5	2.5
Waste Disposal & Recycling	14.8	17.1	17.1	19.6	19.6
Miscellaneous	6.2	6.3	6.3	6.3	6.3
TOTAL	1,041.5	1,294.0	1,294.0	1,519.4	1,519.4

Pollutant/Source Category	1990	2000 Pre-CAAA	2000 Post-CAAA	2010 Pre-CAAA	2010 Post-CAAA
PM_{10}					
Fuel Comb. Industrial	29.1	37.1	37.1	43.8	43.8
Fuel Comb. Other	510.7	470.1	469.6	398.8	398.3
Metals Processing	<0.1	<0.1	<0.1	<0.1	<0.1
Petroleum & Related Industries	1.6	1.3	1.3	1.2	1.2
Other Industrial Processes	34.6	37.9	37.9	44.2	44.2
Waste Disposal & Recycling	218.2	240.7	240.7	261.6	261.6
Natural Sources	2,092.4	2,092.4	2,092.4	2,092.4	2,092.4
Miscellaneous	23,501.7	23,915.2	23,262.0	23,947.9	23,189.6
TOTAL	26,388.4	26,794.7	26,141.0	26,790.0	26,031.3
$PM_{2.5}$					
Fuel Comb. Industrial	14.8	18.8	18.8	22.2	22.2
Fuel Comb. Other	495.8	453.0	452.2	379.3	378.3
Metals Processing	<0.1	<0.1	<0.1	<0.1	<0.1
Petroleum & Related Industries	1.6	1.3	1.3	1.2	1.2
Other Industrial Processes	22.6	25.1	25.1	29.3	29.3
Waste Disposal & Recycling	190.7	210.1	210.1	228.1	228.1
Natural Sources	313.9	313.9	313.9	313.9	313.9
Miscellaneous	4,769.0	5,016.9	4,911.3	5,296.1	5,173.0
TOTAL	5,808.0	6,038.7	5,932.7	6,270.2	6,146.0
NH_3					
Fuel Comb. Industrial	7.3	9.1	9.1	10.7	10.7
Fuel Comb. Other	7.7	8.8	8.8	10.0	10.0
Other Industrial Processes	35.5	42.5	42.5	49.7	49.7
Waste Disposal & Recycling	81.8	100.7	100.7	119.2	119.2
Miscellaneous	3,593.8	4,650.6	4,650.6	5,542.2	5,542.2
TOTAL	3,726.1	4,811.6	4,811.6	5,731.8	5,731.8

* The totals reflect emissions for the 48 contiguous States, excluding Alaska and Hawaii. Totals may not add due to rounding.

Reasonable Further Progress Requirements

The Post-CAAA scenario incorporates the effect that Title I ozone controls will have on the emissions of VOC and NO_x, both ozone precursors. The ozone nonattainment provisions in this section of the 1990 CAAA state that areas not in compliance with the ozone national ambient air quality standard (NAAQS) must reduce precursor emissions. NAAs classified as moderate, serious, severe, or extreme all are directed to meet the required rate of progress (ROP), and by 1996, cut annual VOC emissions by 15 percent from 1990 levels. In addition, serious, severe, and extreme ozone NAAs must continue reducing precursor emissions after the 1996 ROP deadline. Areas falling into these three categories are required to make reasonable further progress (RFP) towards attainment. To satisfy this regulation NAAs must cut VOC levels by 3 percent annually until they comply with the ozone NAAQS.[6]

For areas to comply with ROP requirements VOC reductions are mandated. For those NAAs that must make additional cuts and satisfy RFP regulations it is possible for NO_x reductions to be substituted for VOC cuts. This trading of one ozone precursor for another is acceptable as long as: 1) a NAA has not been given a NO_x waiver, and 2) the substitution of NO_x for VOC does not result in a greater reduction of NOx than is necessary for an area to comply with the ozone NAAQS.

The ROP and RFP requirements are designed to establish a minimum standard for reducing ozone precursor emissions. In many cases, nonattainment areas satisfy these two regulations simply by complying with other ozone provisions of the CAAA. Reduction of VOC and NO_x, below 1990 baseline levels, made in order to meet other standards, are credited towards ROP/RFP requirements. These credited reductions, although captured by the Post-CAAA scenario, are not a direct result of ROP/RFP standards. To accurately capture the influence of ROP/RFP requirements in the Post-CAAA scenario it was necessary to predict which NAAs would have to make emissions cuts solely for the purpose of satisfying these progress requirements, which precursor(s) would be cut, what the size of the cuts would be, and which sources would be forced to make these cuts.

For the purpose of the prospective analysis it was assumed that NAAs working to satisfy ROP and RFP requirements would, whenever possible, first take credit for all available NO_x reductions and then for all available VOC reductions; any remaining shortfall, corresponding to cuts that NAAs would have to make specifically to meet ROP or RFP requirements, would be made up through additional VOC emission reductions. The size of the total shortfall for all NAAs, thus, is a measure of the impact of these Title I progress requirements on the emission of ozone precursors. This shortfall is captured by the Post-CAAA scenario.

To estimate the VOC shortfall, a separate daily VOC target and daily NO_x target was calculated for the years 2000 and 2010 for every NAA subject to Title I progress requirements. These target figures represent the daily maximum allowable emissions levels that NAAs cannot exceed if they are to comply with ROP/RFP standards. The NO_x target was set according to how much NO_x credit it was assumed will be counted towards ROP/RFP requirements, and the VOC target was set based on the assumption that the remainder of the emissions cuts needed to satisfy ROP/RFP requirements will come through reductions in VOC. The difference between the VOC target and the expected level of daily VOC emissions in the absence of ROP/RFP requirements, represented by ozone season daily (OSD) emissions estimates, equals the shortfall.

Table A-13 shows, for each NAA subject to ROP/RFP requirements, both the OSD and target VOC and NO_x emissions levels for 2000. Table A-14

[6] The prospective analysis does not model for attainment. For the purposes of this analysis NAAs are assumed to make reasonable further progress until their respective attainment deadlines, as outlined in the CAAA, are reached.

contains the same information for projection year 2010. In addition, these tables indicate whether or not an area has a NO_x waiver (these areas cannot be given NO_x credit towards RFP), and reveal how RFP reductions were divided between VOC and NO_x in order to calculate the target values for both ozone precursors. For example, looking at Table A-13 shows that for Philadelphia in the year 2000, NO_x reductions of 18 percent from 1990 base year levels are credited towards satisfying RFP provisions. After accounting for this credit, the maximum daily VOC emissions that is allowable for Philadelphia, if this area is to comply with progress requirements, is 1,376.55 tons. Since this VOC target value is greater than the predicted level of daily emissions (VOC OSD) of 1,090.49 tons, there is no shortfall. For Philadelphia in the year 2010 (Table A-14), however, an additional 9 percent reduction from 1990 VOC emission levels is necessary in order to satisfy RFP requirements. Once again there is no shortfall.

After calculating the shortfall for each NAA, EPA estimated how these additional VOC reductions would be achieved. The Agency compiled a list of the available area and point source controls and assumed that each NAA would adopt the most cost-effective measure, followed by the second most cost-effective option, and so on until the area satisfied its ROP/RFP requirements. Table A-15 displays the control option identified by EPA and lists them in the approximate order the Agency believed they would be selected by NAAs attempting to eliminate shortfall emissions. In general, it is assumed that nonroad controls would be the last to be selected, along with AIM coatings. Furthermore, since most areas in the analysis already have reformulated gasoline and I/M programs in the baseline, these were not considered as potential discretionary measures. It should be noted that episodic bans are not creditable towards ROP shortfalls. These measures were chosen to be illustrative of what individual areas might select to meet ROP shortfalls, however, individual areas may select measures that differ from those modeled here. Some of the measures may be politically infeasible for some areas, however, the cost thresholds used to estimate the costs of these measures are consistent with those used in the ozone NAAQS analysis.

Shortfalls are the greatest and most difficult to eliminate in severe ozone NAAs with NO_x waivers. These areas have to meet significant ozone precursor reduction requirements solely by cutting VOC emissions. In Chicago and Milwaukee-Racine, both wavier areas, the VOC shortfall is so large that it cannot be eliminated even if all of the identified controls are implemented. As a result, for these two NAAs it is assumed that unidentified controls are adopted to reduce the remaining shortfall. In all other areas, however, the required reduction can be achieved with the identified controls.

Table A-13
2000 Rate of Progress Analysis

Att. Class.	Att. Date	Ozone Nonattainment Area	2000 OSD (tons per day)[1] NO_x	2000 OSD (tons per day)[1] VOC	Target Selection[2]	NO_x Target	VOC Target	Shortfall
Ser.	1999	Atlanta	420.93	518.94	1%NO_x/8%VOC	426.28	476.35	42.59
Mod.	1996	Atlantic City	46.11	37.97	ROP - 15%VOC	0.00	45.71	0.00
Sev.	2005	Baltimore	335.42	318.33	18%NO_x	381.53	376.47	0.00
Ser.	1999	Baton Rouge	449.70	203.77	NO_x waiver	0.00	415.65	0.00
Ser.	1999	Beaumont-Port Arthur	245.20	340.66	NO_x waiver	0.00	450.66	0.00
Ser.	1999	Boston-Lawrence-Worcester-E.MA	560.20	822.65	9% NO_x	602.06	918.01	0.00
Sev.	2007	Chicago-Gary-Lake County	1,056.70	1,240.89	NO_x waiver	0.00	1,202.25	38.64
Mod.	1996	Cincinnati-Hamilton	378.70	305.34	ROP - 15%VOC	0.00	341.18	0.00
Mod.	1996	Cleveland-Akron-Lorain	369.12	521.14	ROP - 15%VOC	0.00	573.07	0.00
Mod.	1996	Dallas-Fort Worth	528.83	694.53	ROP - 15%VOC	0.00	673.97	20.56
Ser.	1999	El Paso	113.35	85.38	0%NO_x/9%VOC	0.00	69.02	16.36
Mod.	1996	Grand Rapids	129.61	182.72	ROP - 15%VOC	0.00	175.66	7.06
Ser.	1999	Greater Connecticut	211.67	316.27	9%NO_x	224.49	370.11	0.00
Sev.	2007	Houston-Galveston-Brazoria	1,094.58	1,426.65	NO_x waiver	0.00	2,268.31	0.00
Mod.	1996	Kewaunee Co Wi	3.23	4.86	ROP - 15 VOC	0.00	4.56	0.30
Mod.	1996	Knox & Lincoln Cos ME	9.26	9.95	ROP - 15%VOC	0.00	10.37	0.00
Mod.	1996	Lewiston-Auburn ME	23.56	34.08	ROP - 15%VOC	0.00	35.98	0.00
Ext.	2010	Los Angeles-South Coast	1,010.32	972.91	1%NO_x/17%VOC	1,019.06	939.08	33.83
Mod.	1996	Louisville	264.00	219.66	ROP - 15%VOC	0.00	215.97	3.69
Mod.	1996	Manitowoc Co WI	13.69	19.72	ROP - 15%VOC	0.00	17.20	2.52
Sev.	2007	Milwaukee-Racine	272.22	327.09	NO_x waiver	0.00	293.24	33.85
Mod.	1996	Monterey Bay	78.60	64.16	ROP - 15%VOC	0.00	79.63	0.00
Mod.	1996	Muskegon	34.25	46.67	ROP - 15%VOC	0.00	44.32	2.35
Mod.	1996	Nashville	167.12	231.71	ROP - 15%VOC	0.00	205.60	26.11
Sev.	2007	New York-N New Jersey-Long Is	1,280.26	1,994.96	18%NO_x	1,553.41	2,407.97	0.00
Sev.	2005	Philadelphia-Wilmingtn-Trenton	678.53	1,090.49	18%NO_x	690.79	1,376.55	0.00
Mod.	1996	Phoenix	404.47	377.43	ROP - 15%VOC	0.00	347.91	29.52
Mod.	1996	Pittsburgh-Beaver Valley	534.53	407.05	ROP - 15%VOC	0.00	399.80	7.25
Mod.	1996	Portland ME	53.72	70.05	ROP - 15%VOC	0.00	73.33	0.00
Ser.	1999	Portsmouth-Dover-Rochester	37.55	53.54	9%NO_x	44.26	58.70	0.00
Ser.	1999	Providence	92.51	173.78	5%NO_x/4%VOC	91.77	180.51	0.00
Mod.	1996	Reading PA	48.66	60.53	ROP - 15%VOC	0.00	61.14	0.00

Att. Class.	Att. Date	Ozone Nonattainment Area	2000 OSD (tons per day)[1] NO_x	VOC	Target Selection[2]	NO_x Target	VOC Target	Shortfall
Mod.	1996	Richmond-Petersburg	141.62	179.97	ROP - 15%VOC	0.00	201.70	0.00
Sev.	2005	Sacramento Metro	164.60	158.01	0%NO_x/18%VOC	0.00	155.08	2.93
Mod.	1996	Salt Lake City	178.25	182.75	ROP - 15%VOC	0.00	150.80	31.95
Ser.	1999	San Diego	228.55	192.90	0%NO_x/9%VOC	0.00	189.71	3.19
Ser.	1999	San Joaquin Valley	499.25	470.50	5%NO_x/4%VOC	505.63	532.41	0.00
Mod.	1996	Santa Barbara-Santa Maria-Lomp	63.77	82.75	ROP - 15%VOC	0.00	83.10	0.00
Mod.	1996	Sheyboygan	38.02	24.49	ROP - 15%VOC	0.00	22.44	2.05
Sev.	2007	Southeast Desert Modified	355.88	227.71	3%NO_x/15%VOC	358.76	219.32	8.39
Ser.	1999	Springfield/Pittsfield-W. MA	112.38	155.51	0%NO_x/9%VOC	0.00	152.42	3.09
Mod.	1996	St. Louis	476.98	465.64	ROP - 15%VOC	0.00	549.14	0.00
Sev.	2005	Ventura Co CA	80.45	65.69	13%NO_x/5%VOC	79.55	70.52	0.00
Ser.	1999	Washington DC	449.80	402.76	9%NO_x	499.12	477.03	0.00

NOTES:
[1]OSD = ozone season daily
[2]The target selection column indicates the percentage reduction of NO_x NAA's are credited towards RFP and what percentage reduction in VOC is then needed to satisfy Title I progress requirements.

Table A-14
2010 Rate of Progress Analysis

Att. Class.	Att. Date	Ozone Nonattainment Area	2010 OSD (tons per day)[1] NO_x	2010 OSD (tons per day)[1] VOC	Target Selection[2]	NO_x Target	VOC Target	Shortfall
Ser.	1999	Atlanta	336.10	492.40	9%NO_x	391.84	541.99	0.00
Mod.	1996	Atlantic City	39.46	33.21	ROP - 15%VOC	0.00	45.71	0.00
Sev.	2005	Baltimore	278.64	293.56	27%NO_x	311.86	376.47	0.00
Ser.	1999	Baton Rouge	407.49	206.65	NO_x waiver	0.00	415.65	0.00
Ser.	1999	Beaumont-Port Arthur	232.32	377.63	NO_x waiver	0.00	450.66	0.00
Ser.	1999	Boston-Lawrence-Worcester-E.MA	478.53	775.66	9%NO_x	602.06	918.01	0.00
Sev.	2007	Chicago-Gary-Lake County	990.61	1,236.73	NO_x waiver	0.00	840.15	396.58
Mod.	1996	Cincinnati-Hamilton	288.20	283.74	ROP - 15%VOC	0.00	341.18	0.00
Mod.	1996	Cleveland-Akron-Lorain	306.32	485.90	ROP - 15%VOC	0.00	573.07	0.00
Mod.	1996	Dallas-Fort Worth	472.66	687.15	ROP - 15%VOC	0.00	673.97	13.18
Ser.	1999	El Paso	113.85	84.33	0%NO_x/9%VOC	0.00	69.02	15.31
Mod.	1996	Grand Rapids	92.07	183.11	ROP - 15%VOC	0.00	175.66	7.45
Ser.	1999	Greater Connecticut	192.62	292.53	9%NO_x	224.49	370.11	0.00
Sev.	2007	Houston-Galveston-Brazoria	1,002.13	1,530.07	NO_x waiver	0.00	1,606.75	0.00
Mod.	1996	Kewaunee Co Wi	2.62	4.77	ROP - 15%VOC	0.00	4.56	0.21
Mod.	1996	Knox & Lincoln Cos ME	8.51	8.98	ROP - 15%VOC	0.00	10.37	0.00
Mod.	1996	Lewiston-Auburn ME	22.20	32.03	ROP - 15%VOC	0.00	35.98	0.00
Ext.	2010	Los Angeles-South Coast	950.39	847.66	5%NO_x/31%VOC	964.60	670.95	176.71
Mod.	1996	Louisville	273.40	216.86	ROP - 15%VOC	0.00	215.97	0.89
Mod.	1996	Manitowoc Co WI	12.10	19.37	ROP - 15%VOC	0.00	17.20	2.17
Sev.	2007	Milwaukee-Racine	246.74	321.89	NO_x waiver	0.00	204.72	117.17
Mod.	1996	Monterey Bay	71.93	61.76	ROP - 15%VOC	0.00	79.63	0.00
Mod.	1996	Muskegon	26.99	46.86	ROP - 15%VOC	0.00	44.32	2.54
Mod.	1996	Nashville	143.58	230.00	ROP - 15%VOC	0.00	205.60	24.40
Sev.	2007	New York-N New Jersey-Long Is	1,148.95	1,842.53	36%NO_x	1,166.20	2,407.97	0.00
Sev.	2005	Philadelphia-Wilmingtn-Trenton	631.39	1,070.05	18%NO_x/9%VOC	632.97	1,194.41	0.00

Att. Class.	Att. Date	Ozone Nonattainment Area	2010 OSD (tons per day)[1] NO_x	VOC	Target Selection[2]	NO_x Target	VOC Target	Shortfall
Mod.	1996	Phoenix	395.64	347.52	ROP - 15%VOC	0.00	347.91	0.00
Mod.	1996	Pittsburgh-Beaver Valley	368.47	358.67	ROP - 15%VOC	0.00	399.80	0.00
Mod.	1996	Portland ME	51.54	66.88	ROP - 15%VOC	0.00	73.33	0.00
Ser.	1999	Portsmouth-Dover-Rochester	33.08	52.49	9%NO_x	44.26	58.70	0.00
Ser.	1999	Providence	75.73	166.61	9%NO_x	87.91	193.15	0.00
Mod.	1996	Reading PA	46.61	55.33	ROP - 15%VOC	0.00	61.14	0.00
Mod.	1996	Richmond-Petersburg	137.12	179.35	ROP - 15%VOC	0.00	201.70	0.00
Sev.	2005	Sacramento Metro	152.59	135.99	1%NO_x/26%VOC	152.62	120.24	15.75
Mod.	1996	Salt Lake City	179.22	189.83	ROP - 15%VOC	0.00	150.80	39.03
Ser.	1999	San Diego	213.59	174.04	5%NO_x/4%VOC	213.42	202.24	0.00
Ser.	1999	San Joaquin Valley	466.55	448.37	9%NO_x	484.34	566.96	0.00
Mod.	1996	Santa Barbara-Santa Maria-Lomp	59.33	81.53	ROP - 15%VOC	0.00	83.10	0.00
Mod.	1996	Sheyboygan	34.84	24.69	ROP - 15%VOC	0.00	22.44	2.25
Sev.	2007	Southeast Desert Modified	329.75	213.87	9%NO_x/27%VOC	332.55	172.34	41.53
Ser.	1999	Springfield/Pittsfield-W. MA	97.63	147.45	7%NO_x/2%VOC	97.87	166.51	0.00
Mod.	1996	St. Louis	381.48	439.47	ROP - 15%VOC	0.00	549.14	0.00
Sev.	2005	Ventura Co CA	75.89	62.33	13%NO_x/14%VO	76.34	63.11	0.00
Ser.	1999	Washington DC	393.57	355.35	9%NO_x	499.12	477.03	0.00

Notes:
[1]OSD = ozone season daily
[2]The target selection column indicates the percentage reduction of NO_x NAA's are credited towards RFP and what percentage reduction in VOC is then needed to satisfy Title I progress requirements.

Table A-15
Discretionary Control Measures Modeled For ROP/RFP

Source Category	Measure	Reduction
Area Source		
Adhesives - industrial	Reformulation	63%
Metal product surface coating	VOC content limits & improved transfer efficiency	30% (50% in 2010 for difficult areas)
Cutback asphalt	Switch to emulsified asphalts (100% RE)	100%
Wood product surface coating	Reformulation	43%
Wood furniture surface coating	Reformulation	43%
Degreasing	Solvent Limits	63% (80% in difficult areas)
Open burning	Seasonal ban	80%
Automobile refinishing	CARB Best Available Retrofit Control Technology (BARCT) limits	47%
Bulk Terminals	Leak Detection and Repair (LDAR)	90% (80% RE)
POTWs	Covers/Adsorption	50%
Bakeries	Afterburner	33%
Petroleum dry cleaning	Recovery dryers	44%
Perchloroethylene dry cleaning	Recovery dryers	70% (80%RE)
Livestock	Recovery system	50%
Miscellaneous surface coating	Reformulation	30%
Aerosols	South Coast Air Quality Management District (SCAQMD) Standards - Reformulation	50% (60% in 2010)
Incineration	Seasonal ban	80%
Synthetic fiber manufacture	Adsorber	78% (80%RE)
Misc. industrial processes	Process change/incineration	50%
Consumer solvents	Additional reformulation	40% (50% in 2010)
AIM coatings	Additional reformulation	40% (50% in 2010)
Lawn & garden	Episodic Ban	50%
Recreational vehicles	Episodic Ban	50%
Industrial equipment	Episodic Ban	50%
Recreational marine	Episodic Ban	50%
Point Source		
Open burning	Seasonal Ban	80%
Industrial surface coating	Add-on Control Levels	90%
Metal product surface coating	Reformulation	88%
Wood product surface coating	Reformulation	85%
Point sources	Rule effectiveness improvements (80% RE to 90% RE)	--

*"Episodic" and "seasonal ban" controls are not creditable toward the ROP shortfall.

Mercury Emission Estimates

EPA, as part of this analysis, also estimates the effect of CAAA provisions on airborne mercury (Hg) emissions for five separate Hg emissions sources: medical waste incinerators (MWI), municipal waste combustors (MWCs), electric utility plants, hazardous waste combustors, and chlor-alkali plants.[7] While the Integrated Planning Model (IPM) was used to generate Pre- and Post-CAAA electric utility Hg emissions estimates, data from previously conducted analyses were relied on to estimate Hg emissions from the other sources. The following section provides a description of the methods and data sources used to develop 1990 base-year Hg emissions and 2000 and 2010 mercury emission projections for the Pre- and Post-CAAA scenarios.

Medical Waste Incinerators (MWI)

During the Maximum Achievable Control Technology (MACT) development process for MWI, 1990 emission estimates for hazardous air pollutants (HAPs), including mercury (Hg), were developed by back-casting 1995 emission estimates (EPA, 1996b). The back-casting was performed by adding to the 1995 database MWIs that had shut down during the 1990-1995 time period. These MWI were shut down as a result of economic considerations prompted by the adoption of strict regulations in six states (California, New Mexico, New York, Oregon, Washington, and Wisconsin). The number of MWIs in the remaining states were assumed to be the same in 1990 as in 1995.

Based on the back-casting analysis described above, EPA estimated Hg emissions of 16 tons per year (tpy) in 1995 and 50 tpy in 1990 (Cocca, 1997). Therefore, 50 tpy is selected as the base year estimate for this analysis. To estimate the Pre-CAAA scenario forecasts, it is assumed that no other states would have adopted MWI regulations between 1995 and 2010. The annual growth rates estimated by the Bureau of Economic Analysis (BEA) for health services are 2.3 percent from 1990 to 2000 and also 2.3 percent from 1990 to 2010 (Pechan, 1998). The Pre-CAAA forecasts were estimated by multiplying 16 tpy in 1995 by a 1.12 growth factor for 2000 and a 1.41 growth factor for 2010. This yielded 17.9 tpy for 2000 and 22.6 tpy for 2010 (see Table A-16).

EPA estimated a 93 to 95 percent reduction of Hg nationally for existing units in the Emission Guidelines (which incorporate the MACT standards for MWI; EPA, 1996c). A 45 to 74 percent reduction was estimated to occur within 5 years of New Source Performance Standard (NSPS) promulgation for new sources (these sources were estimated to produce 0.2 tpy without the standard by 2002). The combined effects of the NSPS/EG are approximately a 93 percent reduction (from 1995) in the years 2000 and 2010. This emission reduction estimate was used to calculate the Post-CAAA emissions for MWI (see Table A-16). No other CAAA regulatory efforts are known that would further impact emissions from MWI.

Municipal Waste Combustors (MWCs)

Methods and sources of information used to estimate Hg emissions for MWC are given in a supporting document for the NSPS/EG for MWC promulgated in 1995 (EPA, 1996c). EPA estimated that there was 54 tpy emitted by MWC in 1990. Between 1990 and 1995, several factors contributed to a decline in Hg emissions from MWC: addition of air pollution controls on existing facilities; retirement of some units; a decrease in the Hg content of municipal waste being burned. EPA estimated that there were 29 tpy of Hg emitted by MWC in 1995 (EPA, 1996c). For the purposes of this analysis, it is assumed that these reductions occurred due to influences unrelated to the CAAA. It is further assumed that no additional reductions would have occurred between 1995 and 2000 (or 2010) without promulgation of the NSPS/EG.

[7]Together, these sources account for 75 to 80 percent of national anthropogenic airborne Hg emissions.

EPA further estimated that following full implementation of the NSPS/EG in 2000, national Hg emissions would be reduced to 4.4 tpy. However, the NSPS/EG was amended in 1997. As part of the amendments, MWC units with capacities less than 250 tons/day and cement kilns burning municipal waste were exempted from the NSPS/EG. Due to this exemption, EPA estimated that 87 percent of the national MWC capacity was now covered by the NSPS/EG (small units were to be covered in a later rule-making; EPA 1997c). Therefore, to estimate Post-CAAA 2000 emissions for MWC, the original 4.4 tpy estimate was divided by 0.87 to account for the exempted units. After adjusting for growth, the 5.5 tpy shown in Table A-16 was estimated for 2000.

Between 1995 and 2000, EPA (1997d) estimated that municipal solid waste combustion would increase by 7.5 percent. Therefore, the Pre-CAAA 2000 Hg emissions were estimated to be 31.2 tpy (29 tpy x 1.075). Between 2000 and 2010, growth in municipal waste combustion is estimated to be an additional 8.3 percent (EPA, 1996f). This growth factor was applied to both Pre- and Post-CAAA 2000 emission estimates to yield the year 2010 estimates.

Electric Utility Generation

In a report to Congress which details anthropogenic mercury emissions, the EPA estimated that total 1990 mercury emissions from utility boilers was 51.3 tpy (EPA, 1996g). The Integrated Planning Model (IPM) was used to estimate emissions resulting from electric power generation in 2000 and 2010 using different control scenarios to reflect the Pre and Post-CAAA scenarios. The results generated by the IPM are presented in Table A-16 (EPA, 1996g). The scenarios modeled did not include any assumptions about the effects of any MACT standard to be promulgated by EPA in the future. Any differences in emissions between the control scenarios are due to shifts in operation between units or fuel changes predicted by IPM (including ash content of the coals as well as switching to natural gas). The modeled emission estimates are based on information available at the time, and if the same analysis were performed today, with currently available inputs, the results could be different.

Hazardous Waste Combustion

Pechan-Avanti received preliminary draft data from Industrial Economics on the benefits of the MACT Standard for hazardous waste combustors (Yates, 1999). No information was available on growth for this source category, although the analyses conducted to date indicate that there might be a slight contraction (e.g., five percent) of the category between 1990 and 2000 (or 2010; Yates, 1999). Therefore, it was assumed that there would not be any growth from the 1990 baseline. Also, it was assumed that emission reductions would not occur until after 2000, since the standard will not be fully-implemented until 2002.

Chlor-alkali Plants

EPA documents estimate mercury emissions from mercury-cell chlor-alkali plants to be 9.8 tpy (EPA, 1998b; EPA, 1998c) in 1990, and 7.1 tpy in 1994 (EPA, 1996h; EPA, 1996i). The number of facilities which use the mercury-cell process has been declining since reaching a peak of 35 in 1970. By 1995, there were 14 facilities, one of which has converted to a membrane process (no mercury emissions), and another of which has ceased operation, leaving 12 facilities in 1999. In the past, closures or process changes have been due to economics rather than regulations. There are no existing CAAA programs which influence mercury emissions from this source. A MACT standard is currently in the development process, and will not be promulgated for a year or more (Rosario, 1999; Dungan, 1999).

The MACT standard, when issued, will focus on both point source and fugitive emissions. There are generally three point sources at mercury-cell chlor-alkali plants which emit mercury: hydrogen vents, end-box vents, and mercury recovery vents. Point source controls being considered for the MACT standard are a combination of a cooling device and either a molecular sieve, or a carbon adsorption system. The level of control is yet to be determined, pending

further investigation into the typical concentrations of mercury found at the vents. The MACT standard for fugitive mercury emissions from the cellhouse has not been identified at this point, and investigations and meetings are planned for the near future in order to quantify typical fugitive emissions (Rosario, 1999).

Assuming that no additional plants will close or convert between the time of this writing and the end of 2000, and that mercury emissions from the 12 remaining sources have remained constant since 1994, and will continue to remain constant, 2000 emissions for both the Pre and Post-CAAA scenario are estimated to be 6.0 tpy. This is based on the 7.1 tpy reported for 1994, minus the 1994 emissions for the two facilities which no longer have the potential to emit mercury (Georgia-Pacific in Bellingham, WA which ceased operations in 1999 and is reported to have emitted 0.65 tpy in 1994, and LCP Chemicals in Reigelwood, NC which converted in 1999 and is reported to have emitted 0.55 tpy).

Future mercury emissions from mercury-cell chlor-alkali plants are assumed to continue to decline, following the trend of plant closing and conversions. Assuming that the decline in the number of mercury-cell facilities has been linear since 1970, and will remain linear in the future, a linear regression was used to estimate the number of facilities in 2010. Assuming that there will be 12 facilities in 2000, the linear regression ($r^2 = 0.98$) indicates a decline of approximately 0.75 facilities per year, which, when extrapolated to future years, results in an estimate that there will be approximately four mercury-cell facilities still in operation in 2010. Assuming that emissions will decline at a rate proportional to that of the number of facilities, emissions are estimated to decline from 6.0 tpy in 2000 to 2.0 tpy in 2010. This estimate was used as the Pre-CAAA scenario estimate for 2010 (see Table A-16).

In order to account for the possible effect of an un-promulgated MACT standard on Hg-cell chlor-alkali plants operating in 2010, the limited information available was reviewed. This information is principally made up of a brief summary of test data submitted by the operating facilities. At some point in the future after more testing has been performed, the MACT standard and estimates of the resulting reductions will be made publicly available (Rosario, 1999).

Currently, there are facilities which control mercury emissions, some of which control the emissions to near or below what the MACT limit may eventually be. Emissions from these sources are unlikely to be reduced as a result of the MACT standard being promulgated. However, emissions from the plants required to upgrade or add control systems as a result of the MACT standard being promulgated, will be reduced in future years. Based on the limited data available, and assuming that the test data available are typical of what would be reported by the facilities for which no valid test data are available, the overall reduction is estimated to be approximately 35 percent. This estimate is reflected in the Post-CAAA emission estimate for 2010 in Table A-16. The difference between 2010 emissions with and without the CAAA will be greater if the number of mercury-cell chlor-alkali plants remains steady at present levels rather than declining at a linear rate, as is assumed here.

Table A-16
Airborne Mercury Emission Estimates

Source Category	1990 Emissions (tons)	2000 Emissions (tons)			2010 Emissions (tons)		
		Pre-CAAA	Post-CAAA	Diff.	Pre-CAAA	Post-CAAA	Diff.
Medical Waste Incin.	50	17.9	1.3	16.6	22.6	1.6	21.0
Municipal Waste Comb.	54	31.2	5.5	25.7	33.8	6.0	27.8
Electric Utility Generation	51.3	63.0	61.1	1.9	68.5	65.4	3.1
Hazardous Waste Comb.	6.6	6.6	6.6	0	6.6	3.0	3.6
Chlor-Alkali Plants	9.8	6.0	6.0	0	2.0	1.3	0.7
Total CAAA Benefits (Reductions)				**44.2**			**56.2**

Uncertainties in the Emission Estimates

This discussion is organized according to the three major sources of uncertainty in the emissions inventory and emission projections: the base year emission estimates, economic growth forecasts, and future year control assumptions.

Base Year Emission Estimates

Of the pollutants covered in this analysis, the most certain emission estimates are those for SO_2. SO_2 is generated during combustion of any sulfur-containing fuel and is emitted by industrial processes that consume sulfur-containing raw materials. Because sulfur emissions are directly related to the fuel sulfur content, as long as fuel usage and fuel sulfur content are measured, SO_2 emissions, prior to the imposition of controls, can be precisely estimated within a narrow range. Electric utilities emit about 70 percent of the SO_2 in the United States. Under existing utility industry regulations, fuel consumption and sulfur content of fuels are regularly reported to DOE. Recent comparisons of Continuous Emission Monitoring (CEM) data for SO_2 with estimates based on SO_2 emission factors and fuel consumption for a sample of plants showed that the two techniques produced emission estimates within an average of 8 percent at a State level. The difference is due, in part, to higher fuel consumption numbers reported by CEM systems, as a result of the missing data substitution requirements of the acid rain program (Schott, 1996).

As part of the GCVTC emission inventory (for 11 Western States), uncertainty estimates were developed for key source sectors, representing over 70 percent of the emissions (Balentine and Dickson, 1995). SO_2 sources examined included copper smelters and motor vehicles. The uncertainty estimate calculated for SO_2 emissions from copper smelting is $\pm$ 50 percent. Diesel and gasoline vehicle emissions have uncertainty estimates of a factor of $\pm$ 1.5. Most of this uncertainty is due to the variability in the sulfur content of the fuels.

After SO_2, the next most certain emission estimates are probably the NO_x values. Like SO_2, NO_x is a product of fuel combustion. However, there are two NO_x sources in fossil-fuel combustion (Seinfeld, 1986). The first is the oxidation of atmospheric molecular nitrogen at the high temperatures of combustion. NO_x formed by this route is referred to as thermal NO_x. The second source is the oxidation of nitrogen-containing compounds in the fuel. NO_x formed by this path is called fuel NO_x. Since NO_x formation is somewhat more complicated than SO_2, emission estimates are more variable, and uncertain, as well.

A comparison of NO_x emissions based on CEM data and NO_x emissions based on AP-42 emission

factors for a sample of utilities in Louisiana resulted in a difference of 22 percent between the two methods. The difference is attributable to improved emission factors resulting from the use of CEM data, rather than one-time stack tests or AP-42 emission factors (Schott, 1996).

The level of uncertainty in primary PM_{10} emission estimates varies widely by source category. The largest component of the 1990 PM_{10} emission estimates is fugitive dust sources, which include paved and unpaved roads, construction activity, agricultural tilling, and windblown dust. The GCVTC study estimated the uncertainty for unpaved road emissions to be a factor of $\pm$ 4.0. The estimated uncertainty for $PM_{2.5}$ emissions from paved road dust is a factor of $\pm$ 1.8.

PM_{10} emission estimates for large point sources such as utility boilers would be expected to be less uncertain than the fugitive dust source estimates, because these stacks are typically controlled using baghouses or electrostatic precipitators, with frequent stack tests to ensure compliance with regulations.

VOC emissions estimates are uncertain because organics are emitted both as a product of fuel combustion and through evaporation. Evaporative emissions are difficult to quantify because of the associated measurement problems. The GCVTC study estimated the VOC emissions uncertainty for motor vehicles to be a factor of $\pm$ 1.5.

Estimates of emissions from solvents and other evaporative VOC sources are probably even more uncertain than the motor vehicle VOC emission estimates. Emission estimates for such sources typically assume that all of the organic content of solvent ultimately evaporates. However, usage patterns determine what time of year these solvents are released to the atmosphere, and emissions that occur outside the ozone season may not influence ozone levels. Solvent emission estimates used in this study are based on a national material balance. Solvent emission estimates made by State and local air pollution control agencies for SIPs typically use per capita emission factors to estimate solvent emissions. This will produce different emission estimates than used in this study.

Growth Forecasts

The 2000 and 2010 emission estimates in this analysis are influenced by the projected changes in pollution-generating activity. Inherent uncertainties and data inadequacies/limitations exist in forecasting growth for any future period. As a result, it was necessary in this analysis to use indicators of growth that may not directly correlate with changes in the factors that influence emissions. In the previous chapters of this report, alternative growth forecasts were presented for major sectors, and the implications of these alternative forecasts were noted.

The best indicator of pollution-generating activity is fuel use or some other measure of input/output that most directly relates to emissions. The key BEA indicator used in this analysis, GSP, is closely linked with the pollution-generating activity associated with many manufacturing industry processes (iron and steel, petroleum refining, etc.). However, a good portion of industrial sector emissions are from boilers and furnaces, whose activity is related to production, but not as closely as product output. Activities such as fuel switching may produce different emission patterns than those reflected in the results of this study. The modeling methods applied in this study would only capture such effects for electric utilities, but not for the industrial sector.

While it is expected that there will be energy efficiency improvements in the 1990 to 2010 forecast horizon, potential energy efficiency improvements have not been incorporated in the growth factors. The U.S. Department of Energy currently estimates that energy intensity – the amount of energy used for each dollar of output in the economy – will decline by 1 percent per year through the time horizon of this study. If these potential energy efficiency improvements had been incorporated in the 2000 and 2010 emission projections, then both the Pre-CAAA and Post-CAAA emission estimates would be lower than those presented in this report.

In general, emissions from the point, area, and nonroad engine/vehicle sectors are projected to 2000 and 2010 in this analysis based on BEA GSP by State and industry, and population projections by State. Source categories were matched with surrogate activity indicators that represent proxies for emission growth. The uncertainty of the growth forecasts used in this analysis is attributable to two factors: the uncertainty of the projections data used, and the use of surrogate activity levels to estimate future emission levels.

Throughout this analysis, efforts were made to identify potential sources of growth surrogates and to evaluate the impacts of alternative growth factors on emission projections. The impact of alternative growth factors on the emission projection results of this study vary by source category and pollutant. For example, point source emissions from chemical manufacturing would increase at an average annual rate from 0.9 (BEA GSP) to 2.6 (E-GAS/WEFA) percent per year between 1990 and 2010 depending on the activity factor used as a surrogate for emissions growth. In the nonroad vehicle sector, emissions from aircraft are projected to grow from 2 to 5 percent per year for the 1990-2010 time period, depending on whether GSP or landing and takeoff operations (LTO) data are used as the surrogate growth indicator. Growth projections for the railroad industry can range from 0.3 percent to 4.4 percent depending on whether the growth variable is ton-miles, fuel use, GSP, or earnings. In this analysis, BEA earnings data were used to represent growth in emissions for this industry because it was possible to differentiate growth rates at the State level, and because the data were available for the relevant years of this analysis. In future years, industry analysts predict lower prices per ton-mile in response to increased competition for rail traffic. To the extent that future predictions of lower rail transport prices occur as railroad transport increases, miles traveled may be a more accurate activity level surrogate for emissions than earnings. The outlook for the railroad industry is uncertain, and emissions may be over- or understated for the 2000 and 2010 scenarios depending on future industry conditions.

Each of the available variables for projecting emissions has advantages and disadvantages with respect to this analysis. The Agency chose growth surrogates for this analysis based on EPA guidance; the availability of data for 1990, 2000, and 2010; geographic detail of projections data; coverage relative to the detail of the base year inventory; and the appropriateness of using the variable as a measure of emissions growth. For this analysis, BEA provided a consistent data set that could be applied across source categories and across States.

Future Year Control Assumptions

The uncertainties associated with future year control assumptions can be grouped in three types: (1) will the control programs be adopted; (2) will control programs be as effective as estimated in this analysis; and (3) will technological shifts produce enough changes in emission patterns to affect future year results?

On the first and second issues, there have been eight years of progress in implementing the CAAA provisions, and emission trends estimates have shown that significant emission reductions have occurred in this period (EPA, 1997a). Relative to expectations when the CAA was passed, SO_2 emission reductions have occurred at a faster rate than originally anticipated, while some of the VOC and NO_x emissions have been less than originally anticipated, as many vehicle emission inspection programs have been delayed. By 2000, though, any short run perturbations may have a negligible effect on overall emission benefits. Future implementation depends on decisions that EPA makes about Federal rules, such as commercial/consumer solvent rules and MACT standards.

Also on the second issue, concerns about the ability of regulations to achieve expected reductions as implemented have resulted in some new programs and techniques for assuring that new programs are effective. Rule effectiveness discounting is applied to stationary source controls (other than those for SO_2) in this analysis to account for control equipment malfunctions and downtime, unrecognized control

responsibility, and gross noncompliance. In addition, much more continuous emission monitoring is now required for major SO_2 and NO_x sources to ensure that emission limits are met, so many point source emission reductions should be verifiable. Verifying area source emission reductions is much more difficult. Experiments using remote sensing, tracers, and other real-world measurement tools are being performed to better assess the effectiveness of motor vehicle, nonroad engine, and solvent emission control initiatives.

On the third issue, any major technological improvements to create lower-polluting systems by 2010 could influence the emission forecasts, and would be expected to produce more emission benefits than have been estimated in this study. In-depth analyses of two sectors, petroleum refining and motor vehicles, as part of the Section 812 prospective analysis found no major technology changes that would significantly alter emission estimates in these two important sectors to be likely before 2010. For the motor vehicle industry, research has been focused on battery-powered electric vehicles since the California LEV program requirement for zero emission vehicles (ZEVs) was announced. However, these electric vehicles will be unlikely to capture more than 10 percent of LDV sales by 2010.

The refinery sector study identified the significant post-1990 technological trends in this industry to be (1) continued investment in downstream processing of petroleum; (2) increasing refinery capacity utilization; (3) continued improvement in refining process control and catalyst use; and (4) steady capital investment in stationary source controls. None of these trends is expected to significantly change refinery emission rates in 2010 apart from the further investment in stationary source controls (to meet MACT standards, for instance) and these are accounted for in the post-CAAA scenario emission estimates.

Air pollution control regulations will be technology forcing in that many VOC containing solvents will be re-formulated to low-VOC solvents or replaced with water-based substitutes. The most significant programs associated with the CAAA that impact VOC emissions from the solvent cleaning source category are being implemented through local regulations as part of ozone attainment plans. Chief among these is the revised SCAQMD Rule 1171 (SCAQMD, 1996). In the revision of this rule, SCAQMD requires the use of low-VOC solvents (e.g., aqueous) for all regulated sources (e.g., those who are not regulated under Rule 1122, which has equipment instead of solvent requirements). SCAQMD is still working on issues surrounding applicability of Rules 1171 and 1122, but has initially estimated VOC emission reductions of 46 percent associated with the revisions to Rule 1171 (SCAQMD, 1996).

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